ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY

OF

PENNSYLVANIA

FOR

1886.

IN FOUR PARTS.

PART I. PITTSBURGH COAL REGION.
PART II. OIL AND GAS REGION.
PART III. ANTHRACITE COAL REGION.
PART IV. MISCELLANEOUS REPORTS.

By the STATE GEOLOGIST.

PART IV.

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A list of the publications of the Survey is appended to this report.

ANNUAL REPORT, GEOLOGICAL SURVEY OF PENNSYLVANIA,

1886.

PART IV.

THE LEHIGH RIVER SECTION.

WITH MAP AND SECTION ON THREE SHEETS, AND TWO SHEETS OF COLUMNAR SECTIONS.

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THE LEHIGH PAINT ORE MINES.

WITH A MAP.

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REPORT ON THE

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REPORT ON THE

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THE LEHIGH RIVER CROSS-SECTION,

measured, mapped, and described in detail,

By Arthur Winslow, *Assistant Geologist.*

Edited by J. P. Lesley.

This special survey of the Subcarboniferous and Devonian rock-exposures along the valley of the Lehigh River was made by Mr. Winslow, under the direction of Mr. C. A. Ashburner in charge of the general survey of the Anthracite Region in Eastern Pennsylvania, between May and October, 1882; the whole amount of time spent upon actual field work being thirty-two days.

The special object of the survey was to obtain a number of carefully measured local sections, for comparison with one another; not so much for understanding the structure of the region, which was already sufficiently well known; as for locating properly the points upon the river where it is crossed by the several anticlinal and synclinal axes which traverse and separate the coal basins west of the river. These points are all referred by Mr. Winslow to the numbered mile-posts of the two railroads, the Lehigh Valley Railroad, and Lehigh and Susquehanna Railroad, which run side by side nearly the entire distance.

Another object of the survey was to determine with more precision than hitherto the relative thicknesses of formations VIII, IX, X, XI and XII; and to represent, upon a vertical cross section, not only their successive risings and fallings, but their general thinning away from the south northward. *

*In Kingston mountain Mr. Winslow makes it 1002′ thick (Sect. 1); at White Haven at least 1183′ (Sect. 5); at Mauch Cnunk 1975′ (Sect. II) On the Schuylkill below Pottsville, where No. XI stands vertical, and can be measured with greater accuracy than at Mauch Chunk, it is 2959′. (G. P. Vol. I. 1858.)

The southern end of the section between Parryville and the Kittatinny mountain was drawn from Dr. Chance's survey of the Lehigh Water gap. (See map and report in Report G. 6), corrected by a special survey of the Paint belt by Mr. Frank Hill (now assistant in charge of the Anthracite Survey) whose report follows Mr. Winslow's in this volume. The structure at Bowmansville is obscured by faults and rolls, but is simpler and plainer west of the river, in the Lizard Creek valley, on the line of section, to which Mr. Hill's interpretation is given, and for which he makes himself responsible.

The belt map accompanying this report has been based upon a 1600′ : 1″ reduction from the office maps of the L. V. R. R. Co.* and L. & S. R. R. Co. The geological distances were got by counting rails, by pacing, and by compass triangulation. Elevations were got by aneroid barometer from railroad grade.

The synclinal conglomerate mountain ends of the coal basins west of the river were carefully located by compass, stadia and vertical arc measurements.

From Rockport to the Nescopec mountain the geology of the section line is inferred from exposures on the railroads at a considerable distance.

Thicknesses of strata in the section tables were got by reducing diagonal distances to a right angle with the strike, and then the horizontal thickness to the normal thickness perpendicular to the planes of bedding.

A section (B) across the Wilkes Barre basin, S. 38° E. taken from the publications of the Anthracite Survey † has been placed upon the first sheet of the maps, and used for the extension northward of Mr. Winslow's section, which starts east of it and runs S. 14° E.

From the Shickshinny (Shawnee) mountain the line crosses the Wyoming valley, between Plymouth and Wilkes Barre ‡; the Wyoming mountain at Solomon's

* Mr. Winslow expresses his gratitude to Mr. A. W. Stedman, Chief Engineer of the L. V. R. R., who on all occasions furnished him with maps and records, and took the liveliest interest in the work.

† Sheets 5 and 6; Ashley section.

‡ West end of Richard's Island.

gap*; the head plateau of Wapwallopen valley†; the Nescopec mountain‡; the Nescopec or Cunningham red shale valley §; Yeager's mountain basin ||; Green mountain basin; East Buck Mountain basin; Big Black Creek basin; Hazleton basin (Pismire hill); Beaver Meadow basin; Bald Ridge anticlinal ¶: Penn Haven basin; the Nesquehoning Mountain waves**; Kettle Mountain anticlinal; the red shale of the Kettle (Panther Creek basin)††; Bear mounttain (Second mountain of Schuylkill county, with nearly vertical north dipping Pocono (X) and Catskill (IX) formations); the great Lehighton anticlinal, (bringing up Chemung and Genesee formations VIII); the Wire Ridge synclinal (IX)‡‡; the Bowmansville anticlinal; the Hazardville synclinal (V); and ends on the Kittatinny mountain (IV) three miles west of the Lehigh Water gap.

The Country traversed by the Section line.

Most of the country traversed by the line of section is uncultivated. The *Wyoming valley* is, of course, an exception to this, its low alluvial flats and adjoining rounded hills being extensively and profitably cultivated. But, from the mountain on the south side of this valley to the vicinity of Tunnel ridge there are large tracts of desolate land. The timber has been almost entirely cleared off, leaving only, here and there, groups of scattered trees, while the ground is covered with a thick, undergrowth of scrub-oak, briars and low vegetation with occasional swampy patches of tall ferns and interlacing rhododendrons. The soil, though occasionally a fine sand, is generally mixed with angular fragments of silicious sandstone.

* East side, so that it does not show the deep red shale valley. The line runs 1000′ E. of Penobscot Knob.

† Crosses Wapwallopen creek 700′ E. of L. V. R. R.

‡ 2000′ E. of 139th M. P. of L. V. R. R.

§ Crosses Tunnel ridge near C. Miller's farm house.

|| A little east of the end of the mountain.

¶ Crosses Quakake Creek 1200′ above its mouth; passes through Morrison; and Rockport 1700′ W. of the point of the Oxbow.

** Crosses to the east side of the river at the old Penn Haven station.

†† One mile east of the river at Mauch Chunk.

‡‡ Crosses the Lehigh 1800′ south of Parryville Station.

In the vicinity of *Tunnel ridge* the country becomes less of a wilderness. The soil is no longer as thickly intermixed with hard rocks, but has more of a red shale character, and cultivated fields are seen.

West of *White Haven* is a broad red shale valley. The ground is thickly covered with blocks of red sandstone; but when these are removed, the soil can be profitably farmed. Near the base of Yeager's mountain the country is little more than an impenetrable briar patch, but susceptible of cultivation.

From this over *Green mountain* a mile of waste land is crossed; but south of this, a broad undulating red shale valley stretches for about five miles to *Rockport.* Although in portions thickly wooded or covered with undergrowth, the red shale soil is largely cultivated.

Further south, over *Bald ridge*, across the eastern extremity of *Nesquehoning mountain*, along the Lehigh river and up over the broad back of *Kettle mountain*, it crosses a rugged and desolate country of sharp ridges, abrupt declivities and steep ascents. Blocks of sandstone and conglomerate of all sizes abound, on a surface covered with a thick underbrush.

The *Kettle* east of Mauch Chunk is a thicket of small trees and bushes.

Bear mountain south of it is a repetition of Kettle mountain.

South of Bear mountain the section passes east of *Packerton*, *Lehighton* and *Weissport*, through a country of gently undulating hills and valleys.* The change of surface marks a change in the geology from silicious sandstones to soft shales; and the numerous farm-houses and cultivated fields indicate the consequent improvement of the soil.

Elevations Above Tide.†

	A. T.
Shawnee Mountain (north end of section,)	1350′
Delaware, Lackawanna & W. R. R. crossing,	530′
Susquehanna River, Richard's Island,	510′

* Recrosses the river to the west side half way between Lehighton and Parryville; 300′ E. of Lock 10.

† From various sources:—Railroad grades; R. R. contoured local maps; angular telescope observations.

	A. T.
L. V. R. R., north of Ashley,	600′
L. & S. R. R., Ashley,	*634*
L. & S. R. R., on north side of Penobscot Mt.,	1500′
Penobscot Ridge,	2000′
Wapwallopen Creek,	1670′
Nescopec Mountain (average elevation),	1900′
L. V. R. R., south of Nescopec Mountain,	1610′
Valley north of Tunnel Ridge,	1300′
Tunnel Ridge,	?
Valley between Yeager Mt. and Green Mt.,	1230′
Nescopec Division of L. & S. R. R.,	*1350′*
Green Mountain,	1550′
Turnpike 700′ north of crossing with Pond Creek,	1340′
Sandy Creek,	?
Sandy Run Branch L. & S. R. R.,	?
East Pismire Ridge,	1600′
Hill north of Laurel Run,	1225′
Laurel Run,	*985′*
Bald Ridge,	*1450′*
Old R. R. bed, top of Plane at Penn Haven Juc.,	1150′
Quakake Creek,	*730′*
Hazleton Branch L. V. R. R.,	*740′*
Nesquehoning Mountain,	1300′
Penn Haven Junction (old station), L. V. R. R.,	*705′*
Little Bear Creek,	700
Top of Kettle Mountain,	1600′
Kettle Valley,	750′
Bear Mountain,	1350′
Hills south of Bear (Second) Mtn, average,	600′
Lehigh river at Canal Lock 10, below Lehighton.	450′

*L. V. RR. Mile-posts.**

157	Sugar Notch,	665′	134	Neighley's cut,	1337′
156		668′	133		1271′
155		713′	132		1206′
154		821′	131	White Haven,	1151′
153		916′	130	Bridgeport,	1119′
152		1012′	129	Lehigh tannery,	1087′
151		1109′	128	Hayes run,	1062′
150		1204′	127	Opp. Sandy run,	1039′
149		1300′	126	Hickory run,	1018′
148		1398′	125	Mud run,	993′
147		1493′	124		955′
146		1591′	123		951′
145	Fairview,	1671′	122		924′
144	Wapwallopen creek,	1687′	121	W. of New tunnel,	897′
143		1703′	120		878′
142		1719′	119	Drake's creek,	859′
141	Nescopec Mt.,	1735′	118	N. of Stony creek,	832′

*From the level books of the Company (A. W. Stedman, Asst. Eng.)

140	. . . .	1695′	117	. . . .	794′
139	. . . .	1631′	116	. . . .	761′
138	. . . .	1567′	115	. . . .	730′
137	Bear Cr. Junc., ...	1516′	114	Old Penn Haven Junct.,	722′
136	Moosehead, ...	1469′	113		696′
135	. . . .	1403	112	Opp. L. Bear Cr., ...	693′
			111	. . . .	656′
			110	. . . .	629′
			109	N. of Glen Onoko, ...	593′
			108	Coal Port, ...	568′
			107	N. of E. M. Chunk, . . .	554′
			106	Mauch Chunk St., . . .	546

*Miscellaneous Elevations.**

Susquehanna river at Wilkesbarre, ...	*520′*
Ashley Plane No. 3, foot *630*; head, ...	*899′*
" Plane No. 2, foot *892*; head, ...	*1314′*
" Plane No. 1, foot *1309*; head, ...	*1648′*
Fairview Station, Lehigh Valley railroad, ...	*1678′*
Penobscot Knob (overlooking Fairview), ...	2120′
Moosehead Ochre Works, L. V. RR., ...	*1469′*
Neighley's Cut, on the L. & Sus. RR., ...	1300′
Yeager's mountain, east end (cliff XII), ...	1750′
Green mountain, east end (cliff XII), ...	1630′
Buck Mountain, east end (cliff XII), ...	1558′
Spring Mountain, east end (cliff XII), ...	1235′
Bald Ridge, ...	1460′
Kettle mountain, ...	1600′
Mt. Pisgah (overlooking Mauch Chunk), ...	1340′
Mauch Chunk, L. & S. RR., ...	*532′*
Lehighton, L. V. RR., ...	*466′*
Lehighton, L. & S. RR., ...	*494′*
Weissport, L. & S. RR., ...	*475′*
Parryville, L. & S. RR., ...	*448′*
Bowmansville, L. & S. RR., ...	*436′*
Hazardville, L. & S. RR., ...	*417′*
Lehigh Gap, L. & S. RR., ...	*393′*
Lehigh Gap, L. V. RR., ...	*389′*
Stony Ridge, east of Lehigh river, ...	850′
Kittatinny (Blue) Mountain crest, ...	about 1500′

List of Sections.

1. Wyoming Mountain Section (XII, X, IX), 4080′.
2. Nescopec Mountain Section (X, IX), 1913′.
3. Moosehead Section (X), 124′.
4. Neleigh's Cut Section (XI), 619′.

*Of different values. Those *in italics* may be assumed to be correct.

5. White Haven Section (XI, X) 1283′.
6. Leslie's Run Section (XI), 164′.
7. Drake's Creek Section (X, IX) 1242′.
8. Stony Creek Section (X), 1007′.
9. Quakake Creek Section (XI, X, IX), 1499′.
10. 113th Milepost Section (IX), 447′.
11. Little Bear Creek Section (IX), 623′.
12. Glen Onoko Section (XI, X), 3430′.
13. Mauch Chunk Section (XII, XI, X, IX, VIII), 13,148′.

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1. Wyoming Mountain section.

From Ashley southward.

For. No. XIII. Coal Measures.

1. Coal, Red Ash bed,	11′	11′
2. Slate, broken,	14′	25′

For. No. XII. Pottsville conglomerate. (220′ thick.)

3. Sandstone, hard, dark, compact,	14′	39
4. Conglomerate, fine, silicious,	19′	58′
5. Slate, fissile,	2′	60′
6. Conglomerate,	24	84′
7. Slate, in separate seams,	1′	85′
8. Conglomerate, medium, silicious,	41′	126′
9. Conglomerate, course, silicious,	119′	245′

For. No. XI. Mauch Chunk red shale (1002′ thick.)

10. Shale, red and green with calcareous bands,	246′	491′
11. Shale, brick red,	120′	611′
12. Sandstone, reddish gray, with quartz and red shale pebbles,	27′	638′
13. Shale and sandstone, red, massive,	335′	973′
14. Sandstone, reddish and greenish gray, with fine quartz pebbles,	31′	1004′
15. Shale, brick red,	60′	1064′
16. Sandstone, fine, greenish gray,	183′	1247′

For. No. X. Pocono gray sandstone (1177′ thick.)

17. Sandstone, white, coarse, silicious,	283′	1530
18. Conglomerate, fine quartz pebbles,	3′	1533′
19. Sandstone, greenish gray, hard,	3′	1536′

20.	Conglomerate, pinkish white, small quartz pebbles, hard,	32′	1568′
21.	Sandstone, white, coarse with pebbles,	40′	1608′
22.	Sandstone, yellowish brown, fissi'e and friable,	38′	1646′
23.	Sandstone, greenish, hard,	44′	1690′
24.	Sandstone, gray, hard, fractured, with pebbles,	57′	1747′
25.	Sandstone, greenish gray, hard, with conglomerate,	256′	2003′
26.	Sandstone, greenish, fractured and shaly,	143′	2146′
27.	Conglomerate, soft slate and sandstone pebbles,	3·	2149′
28.	Sandstone, hard, greenish, much fractured, occasional slate pebbles,	112′	2261′
29.	Sandstone, greenish gray,	163′	2424′

For. No. IX. Catskill red sandstone.

30.	Shale, brick red,	247′	2671′
31.	Sandstone, green and gray,	84′	2755′
32.	Sandstone and shale, red and reddish gray,	141′	2896′
33.	Sandstone, green, fine with broken slate,	14′	3910′
34.	Sandstone, gray, coarse, hard,	28′	2938′
35.	Sandstone and shale, red,	15′	2953′
36.	Sandstone, gray, hard,	4′	2957′
37.	Sandstone and shale, red,	30′	2987′
38.	Sandstone, white, coarse, very hard,	17′	3004′
39.	Sandstone and slate, greenish,	11′	3015′
40.	Conglomerate, sandy,	3′	3018′
41.	Sandstone, gray, very hard,	11′	3029′
42.	Sandstone or slate, red, soft,	17′	3046′
43.	Sandstone, yellowish, friable,	34′	3080′
44.	Sandstone or slate, soft red,	34	3114′
45.	Sandstone, green (broken and soft near bottom),	22′	3136′
46.	Slate, red, fine, soft,	41′	3177
47.	Sandstone, chocolate gray, hard,	26′	3203′
48.	Sandstone, red, slaty at top,	18′	3221′
49.	Sandstone, gray, hard, with pebbles,	35′	3256′
50.	Sandstone, yellow, friable,	4′	3260′
51.	Sandstone, gray, hard,	8′	3268′
52.	Sandstone, dark gray, fine, few pebbles,	82′	3350′
53.	Sandstone, gray, hard, silicious,	87′	3437′
54.	Conglomerate, dark, fine with shale,	6′	3443′
55.	Shale, soft, red,	5′	3448′
56.	Sandstone, chocolate, hard,	13′	3461′
57.	Shale, red, clayey,	24′	3485′
58.	Sandstone, friable, greenish,	18′	3503′
59.	Sandstone, friable, yellowish,	15′	3518′
60.	Sandstone, green, compact,	21′	3539′
61.	Concealed,	20′	3559′
62.	Sandstone and shale, red, soft,	48′	3607′
63.	Sandstone, yellowish,	11′	3618′
64.	Concealed,	133′	3751′

65.	**Sandstone, coarse, grayish green, mica scales, weathers black,**	**164′**	**3915′**
66.	**Concealed,**	**38′**	**3953′**
67.	**Sandstone, gray, fine, shaly,**	**12′**	**3965′**
68.	**Sandstone, red, hard, shaly,**	**14′**	**3979′**
69.	**Slaty sandstone, gray, micacious,**	**3′**	**3982′**
70.	**Concealed,**	**14′**	**3996′**
71.	**Sandstone with mica, red,**	**6′**	**4002′**
72.	**Concealed,**	**9′**	**4011′**
73.	**Sandstone, red, slaty,**	**10′**	**4021′**
74.	**Concealed,**	**6′**	**4027′**
75.	**Sandstone, shaly, mica, pebbles,**	**25′**	**4052′**
76.	**Sandstone, brown and grayish green, with mica scales,**	**28′**	**4080′**

Notes to the above Section I.

The Wyoming mountain is the south rim of the Northern anthracite coal field, in which Wilkes Barre, Pittston, Scranton and Carbondale are the principal places. It is described, mapped and sectioned in Reports AA, and the Annual Reports of 1885 and 1886, to be continued in the Annual Report for 1888.

The formations of the above section 1 dip steeply northward under the coal measures; Wyoming mountain being made by the outcropping massive grey Pocono sandstones of No. X; the outcrop of the Pottsville conglomerate No. XII making a terrace along the slope facing Wilkes Barre; but a separate ridge west of Solomon's gap; the interval becoming a deep narrow vale of vertical Mauch Chunk red shale No. XI. The crest of the Wyoming mountain east of the gap is about 2000′ A. T. but rises to 2120′ in Penobscot Knob, at the gap, and then falls to 1700′ or 1800′ west of the gap, and so continues to the Susquehanna river. This lower elevation is caused by an extra erosion of vertical dips. East of the gap the dips diminish and the mountain crest rises.

South of the mountain is a broad high anticlinal plateau, with nearly flat rocks, and then the Pocono No. X. descending southward makes Nescopec mountain. This plateau is the eastern head of the Wapwallopen valley, which rising eastward is merged in the great upland of the upper Le-

high river country. Two or three ridges traverse the valley plateau and terminate abruptly near Penobscot village.

The section begins at the outcrop of the bottom Red Ash coal bed,* at Ashley, exposed at the north end of the long rock cut about the middle of Plane No. 3 in Solomon's gap.

No. XII. The Pottsville conglomerate XII succeeds this conformably, constituting the bulk of the cut rock; almost a continuous mass of white quartz pebbles in a silicious matrix, about 200 feet thick. The size of the pebbles increases towards the bottom.

Fault. Near the center of the cut is a decided longitudinal fault; the plane of fracture dipping about 34° (N. N. W.). The overlying rock is bent over in an anticlinal roll from its north dip (about 40°) to a south dip. The underlying rock is polished and grooved, and nearly horizontal. There seems to be a downthrow on the south side, the amount of which can not be measured, because no bed can be identified on the two sides; but it cannot exceed 100 feet vertical; for that would have brought the overlying coal measures into view.

About 100′ south of the first bridge over Solomon's creek, the conglomerate outcrop ceases abruptly, with a N. N. W. dip of about 30°.

No. XI. The *Mauch Chunk red shale* underlies the conglomerate conformably from south of the bridge to about 1000 feet up Plane No. 2. The upper 200 feet or so (10) of this formation are here red and green shales; the green, largely scattered through the red in irregular masses, are more or less calcareous and weather out, leaving a pitted, worm-eaten rock.

The two sandstone bands (12) and (14) are prominent members of this formation The upper one (12), exposed in the rock cut about 1000 feet north of the engine house of Plane No. 1, is a reddish gray sandstone, conglomeritic in places, with both quartz pebbles and red shale pebbles. The contact with the underlying red shale is irregular, indicating current erosion. The lower band (14) crops out at

* Top coal, 10″; slate, 2″; coal, 36″; slate, 8″; bottom coal, 76″; total, 11 feet; dip about 45° (N. N. W.)

the foot of Plane No. 2 and resembles the upper one in almost every particular.

The band of fine, greenish sandstone (16) which I have placed at the base of No. XI reaches about 1000′ up Plane No. 2. Its texture resembles the shales of No. XI; its color and material would place it with the green sandstones of No. X. It probably represents the red and green transition beds of X and XI elsewhere.*

No. X. The *Pocono sandstone* extends from near the middle of Plane No. 2, southwards, to within about 800 feet of the lowest crossing of the turnpike over Plane No. 1; with a somewhat flattening (N. N. W.) dip of between 20° and 30°.

Although there are no very marked distinctions between the members of this formation, the upper portion is seen to consist of coarse white sandstone, with one well marked conglomerate (20); the lower portion, of much fractured, greenish and somewhat shaly sandstones.

Iron ore. Near the engine house of Plane No. 2 a small bed of iron ore is said to outcrop under the ash heap.

No. IX. The *Catskill shales and sandstones* begin about the middle of Plane No. 1, and continues southward. The transition from X to IX on the Plane is sharp. Bright red shales (30) immediately under greenish sandstones, are exposed in the long rock cut continuously to beyond where the turnpike passes under the plane; followed by underlying gray and green sandstone, but too imperfectly exposed to be accuratley measured. Red and reddish gray sandstones and shales then follow to the top of Plane No. 1. From here southwards, past the engine house, around the curve, and through the long rock cut of the Lehigh and Susquehanna R. R., there is an almost continuous exposure of red and green sandstones and shales. A hard, gray, pebbly sandstone (49–54) succeeds beneath these shales, in the rock cut, about 300 feet north of the Lehigh Valley R. R. crossing; dipping about 15° (northwards).

Fault. At 100 feet or so north of the railroad crossing, the rock is traversed by a longitudinal fault, dipping

* See pp. 1348, 1351, 1359 and 1361.

about 26° (N. 10° W.); and there is the same recurving of the overlying strata and flattening of the underlying which was observed in the fault in the Pottsville-conglomerate, above described, and which indicate a downthrow on the south. The extent of this slide cannot, however, be great, as the rocks underlying and overlying it are similar. These rocks continue to the end of the cut, and then, passing up to the Lehigh Valley R. R., crop out as far as the north-end of the curve south of the station.

Red and green shales and sandstones with a cap of soft slaty conglomerate (54–60) succeed this along the curve. Then follows a long concealed interval to the next outcrop (62 and 63) about 1000′ north of Wapwallopen creek. Though this outcrop is separated by nearly a mile from the last one, the direction of the dip of the rocks is such that the latter is probably very nearly the stratigraphical continuation of the former.

A broad concealed (64) area succeeds, and then the remaining members of the section are exposed at intervals along the west bend of the railroad south of Wapwallopen creek as far as a point some 2400 feet south of the 143 mile-post.

Outcrops away from the lines of the railroads though in places abundant, are scattered. Up the north slope of Penobscot mountain Pocono rocks were observed with a N. N. W. dip of about 15° which, agreeing nearly with the slope of the mountain, exposes frequently large sheets of hard gray sandstone at the surface. The summit of Penobscot mountain is divided into two crests and the southern one is almost entirely composed of the upper white, silicious Pocono rocks while the northern one, with *Penobscot knob* is composed in its upper part of the lower greenish sandstones of No. X; while lower down the south escarpment of the mountain the Catskill red shales crop out.

A mile or so east of *Penobscot village* there are frequent exposures of gray silicious sandstones lying nearly flat along a low ridge which, trending eastwards from Penobscot mountain, gradually bends around to the south until it coalesces with the north flank of Nescopec mountain near Crystal lake.

Dips. As previously mentioned, the rocks through which the section was measured have a continuous northerly dip; but there are many fluctuations. North of the fault in the Pottsville conglomerate XII, near the foot of Plane No. 3, the dip is about 45° N. N. W. while south of this it averages about 30° for some distance into the Red Shale XI. At the foot of Plane No. 2 it has declined to about 20° and then there is a steepening in the dip of the Pocono X rocks to over 25° up to near the head of Plane No. 2. After this the rocks flatten almost continuously to a dip of 12°, a little south of Fairview. In the outcrops to the south of this, the dips become still less, until at the end of the section they are horizontal and even arch over towards the south.

The direction of dip also changes:—at the foot of the Planes N. N. W.; along the upper Plane almost N.; near Fairview, easterly; at the base of the section about N. 30° E.

From the southmost exposure of Section 1 there is an entire absence of outcrops along the Lehigh Valley R. R. for about two miles to the Summit rock cut of the Nescopec mountain; and none were observed over the adjoining country.

2. Nescopec Mountain section.

*From the Summit Rock cut, southward, along the Lehigh Valley railroad, to Nescopec, on the south slope of the mountain. South dips.**

For. No. X. Pocono gray sandstone.

1. Sandstone, white, hard, silicious, with pebbles,	10′	10′
2. Concealed,	422′	432′
3. Sandstone, gray, fractured, hard,	49′	481′
4. Concealed,	350′	831′
5. Sandstone, gray, coarse,	12′	843′

* The bottom rocks of the section are exposed in the rock cut on the top of the mountain. The top rocks of the section are reached at Nescopec village. But the numerous concealed intervals make this section merely illustrative of the general geology of the mountain.

6.	Sandstone, white, fine, silicious,	24′	867′
7.	Concealed,	77′	944′
8.	Sandstone, olive green, fine,	13′	957′
9.	Sandstone, light green, coarse,	13′	970′
10.	Concealed,	140′	1110′

*For No. IX. Catskill red sandstone.**

11.	Slate and shale, bright red,	54′	1164′
12.	Concealed,	600′	1764′
13.	Sandstone, gray, coarse, black weathered grains,	32′	1796′
14.	Sandstone, greenish, hard, fine, slate pebbles,	24′	1820′
15.	Slate and shale, bright red,	26′	1846′
16.	Sandstone, hard, gray,	30′	1876′
17.	Shale, chocolate red,	28′	1904′
18.	Sandstone, green, fissile,	9′	1913′

Notes on the above Section 2.

The Nescopec mountain makes the north rim of the great Cunningham red shale valley all the way west to Cattawissa; but eastward, merges, like the Wyoming mountain, in the great wilderness upland of the upper Lehigh river country. Where the section line crosses it, it has already ceased to be a well defined mountain ridge, with a short steeper slope northwards, and a long gentle slope southward. Its average elevation is about 1900′ A. T.

Bed (1) at the top of the section is exposed on the railroad, about 500′ south of the 138th mile post.

(3) is seen in a small rock cut just south of the R. R. bridge over N. fork of Nescopec creek, near the 139th mile post.

(5 to 11) crop out at intervals near mile post 140.

(13 to 18) show continuously in the long cut at the summit.

Dips of section beds, pretty uniformly between 10° and 15° (S. S. E.)

Along the Lehigh and Susquehanna railroad there are a few scattered rock exposures which indicate the same distribution of red and green shales, overlaid by hard gray

* This place is assigned to the horizon of separation between X and IX, not from anything seen on the ground, but merely by inference from a comparison of sections 1 and 2.

sandstone. Thus, at the summit station, and to the south of it, there are several outcrops of red and gray shales and sandstones which are, without doubt, the continuations of those exposed near the summit on the Lehigh Valley railroad. About two miles south of this, along the railroad, white silicious sandstone is seen.

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3. *Moosehead section.**

Along the L. V. R. R.; Ochre mine; dips, 10° (N.)

Conglomerate, gray, silicious, medium,		20′
Sandstone, gray,		4
Conglomerate, gray,		6′
Sandstone, gray,		3′
Conglomerate, gray,		3′
Sandstone, gray,		7′
Sandstone, gray, with quartz and red shale pebbles,		15′
Conglomerate, slate pebbles, large red shale fragments,		5′
Sandstone, hard gray,		5′
Shale, red, with red ochre,		28′
Shales, yellowish green,		10′
Ochre, yellow,	Luzerne O. M. Co. mines,	16′
Ochre, white,	Luzerne O. M. Co. mines,	2′
Total,		124′

*From the summit of Nescopec mountain the two railroads descend the slope eastward four miles to its base at Moosehead, four miles north of White Haven.

Cunningham or Nescopec valley is divided into two by Yeager's mountain. Nescopec creek drains west between Nescopec and Yeager's mountain. Green mountain run flows east (to White Haven) between Yeager's & Green mountains.

The Nescopec creek valley is subdivided by Tunnel ridge (extending a mile or more west of the L. & S. R. R. tunnel), and consists of rolling No. XI. rocks.

Yeager's mountain, capped by No. XII is a synclinal outlier of the Eastern Middle coal field (not an anticlinal of Pocono No. X, as represented by the map in Geol. Penn., 1858).

Green mountain is a sharp synclinal coal basin, its end capped with No. XII, only half a mile wide, but extending east to within a mile of the Lehigh river (a little south of White Haven) as a long spur of upper red shale of No. XI, holding beds of gray and greenish sandstone.

Notes on the above Section 3.

Within the half mile north of the Luzerne Ochre Manufacturing Co's mine the conglomerate is exposed horizontal. The ochre mine is on an anticlinal, the ochre bed arching over to a south dip.

The ochre is a soft crumbling rock chiefly of buffish yellow color, but also, in one or two bands, of a whitish and a variegated dark color.

Analysis by Hugh Hamilton.—Water, 0.85; organic matter, 4.50; silica (largely free and destructive to the millstone), 57.36; protoxide of iron, 1.62; peroxide of iron, 2.94; alumina, 27.44; sulphate of lime, 1.93; sulphate of magnesia, 0.66; =97.30.

The ochre is mined in an open cut; taken to the mill in small cars, pushed by men; thoroughly dried in long coffee roasters; hoisted; ground; rehoisted and bolted like flour. As much as 3000 tons have been mined in one year. It is much used in oil-cloth printing.

The tunnel of the Lehigh and Susquehanna R. R. through *Tunnel ridge* is mostly through the red shales overlying the ochre; though they seem to be somewhat thicker at the tunnel than at the mine. The northern portion of the tunnel is through the overlying harder gray rocks, and the ochre bed crops out about 500 feet south of the south end of the tunnel. The rocks dip mostly about 5° (northwards); but at the north end they are about horizontal; at the south end they arch over to a south dip, badly exposed. In the valley, north-west from the tunnel, red shale occurs with a slight south dip.

Considering the structure as exhibited at the ochre mine and at the tunnel, and as further studied east of the railroads, along Wright's creek, this series of gray sandstones and red and yellow shales seems to exist as a flat synclinal to the north of Tunnel ridge and to overlie the south dipping Pocono rocks which constitute the south slope of Nescopec mountain. These rocks should be thus placed at the base of the Mauch Chunk red shale XI.

South from Moosehead, the Lehigh Valley R. R. crosses first a shallow synclinal with hard red sandstone exposures. But, about 1800 feet north of Neleigh's cut, an outcrop of gray sandstone and fine conglomerate (which is doubtless the continuation of that overlying the red shale at Moosehead) marks the axis of a flat anticlinal, and south of this there is an almost continuous exposure of south dipping hard red sandstone and shale for over half a mile to the middle of the big bend in the railroad.

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4. Neleigh's cut section.

North of White Haven, on the L. V. R. R.

For. No. XI. Mauch Chunk red shale.

1.	Sandstone, chocolate red, hard, with shale, . . .	465′	465′
2.	Concealed,	119′	584′
3.	Sandstone, greenish gray, hard, ...	30′	614′
4.	Conglomerate, fine, silicious, red shale pebbles, .	5′	619′
5.	Sandstone, white hard, ...	——	——

Notes on the above section 4.

The rocks at the top of section IV are near a synclinal axis. South of this the red sandstones have a north dip. About half a mile beyond the 133 mile post the underlying gray rocks are exposed; but, near where the wagon road crosses the railroad they arch to the south into a broad shallow synclinal, crossed by the long tangent in the railroad just north of White Haven. At the south end of the tangent these rocks are brought to the surface with a northerly dip; but, after a broken exposure for about 1000 feet, they dip again (south,) under *White Haven.*

On the east side of the river, the gray silicious rocks underlying the red sandstone are well exposed along the bluffs, being lifted by the rise of the basin eastward.

5. *White Haven section*

From White Haven, northward, along the L. & S. R. R. to Lehigh Tannery.

For. No. XI. Mauch Chunk red shale (probably 1700′.)

1.	Shale and sandstone, red,	173′	173′
2.	(Red shale?) . . . concealed,	107′	280′
3.	Sandstone and shale, red,	630′	910′
4.	Sandstone and conglomerate, gray green, pebbles of red shale,	50′	960′
5.	Shale, red,	78′	1038′
6.	Sandstone, red, coarse, with green shale,	38′	1076′
7.	Shale, yellow, ochrey,	18′	1094′
8.	Shale, red,	19′	1113′
9.	(Red shale?) . . . concealed,	70′	1183′

No. X. Pocono Sandstone.

10.	Sandstone and conglomerate, gray silicious,	100′	1283′

Notes on the above section 5.

White Haven is chiefly built upon south dipping strata of red sandstone; but, about 1000 feet north of the crossing of the Lehigh Valley and Lehigh and Susquehanna railroads is the center line of a broad synclinal; south of which a long succession of rocks (dipping between 10° and 15° N. W.) are well exposed along the Lehigh and Susquehanna railroad.

The top of this section must be at least 400 feet below the top of No. XI; for, west of the river on *Green mountain*, near the axis of the synclinal, red shale occurs at this elevation above the railroad, and probably extends still farther up; and that without making allowance for the axial depression westwards. Total *thickness* of No. XI *near White Haven* therefore, probably, 1700′.

No. XI on Green and Yeager's mountains has intercalated beds of gray and greenish sandstone, some of them at least 20′ thick. Overlying them are variegated red and green shales. These alternations are well exposed in the rock cuts near the trestle of the Nescopec Branch of the Lehigh and Susquehanna R. R. about 2 miles west of White Haven.

Limestone nodules are numerous in the upper red shales of For. XI. They are often half an inch in diameter; when dissolved out, by weather, they leave a honeycombed or pitted outcrop, as described already (page 1340). They curiously resemble rolled pebbles.

(4.) Gray and green sandstone near the base of the section appear about 1500′ north of the river bridge at Lehigh Tannery, underlaid by red and yellow ochrey shales, probably identical with those at the Moosehead ochre mine.

The Lehigh Tannery river bridge is near the sharp synclinal axis in upper Pocono rocks, No. X, which are exposed along the L. & S. RR., south from the bridge, for about 1600′, with N. dips; arching then over a sharp anticlinal to 30° (S. E.). Red shales (XI) succeed, the dip flattening to about 10°, cropping out along the south bank, where the river makes the sharp east bend, as far as *Hayes' run.*

A few hundred feet further, around the next bend of the river, the axis of a shallow synclinal is reached; then the rocks rise with a slight north dip (about 5°), which continues for nearly a mile, to a little north of *Sandy run.*

In this interval of a mile, green and gray sandstones (lower XI) are first exposed for about 1000′; followed by a concealed break of nearly 2000′; then hard gray upper Pocono (X) crop out to Sandy run. About 800 feet north of the Sandy run, however, there is a local flattening of the dip to horizontal; then, after a small roll, a dip of 30° (S. S. E.), continuing through the upper (X), and lower (XI) red, green and yellow shales and sandstones to about 1000 feet south of Sandy run.

Here there is a synclinal axis in hard red sandstone; thence, onward, a north dip of about 10°, as far as *Hickory run*, where Pocono rocks are exposed dipping between 30° and 40° (N. N. W.)

From Hickory run to *Leslie's run*, about a mile, the river makes an almost continuous exposure of upper Pocono, hard, white, silicious sandstones; conglomeritic in places, and with greenish bands. The northern portion of this exposure exhibits several sharp waves, and the southern portion a few more, but less abrupt.

At Leslie's run these rocks arch over to a south dip of 35°, and pass under the red rocks of XI.

South of Leslie's run the Mauch Chunk rocks (No. XI) are nearly horizontal for about 600′; then dip 20° southwards for about 700′; the next 1000′ crosses a flat synclinal (with minor undulations); dip, 15° (northwards) on its south side.

Between this and *Mud run* are several small, well marked flexures.

At *Mud run*, the Lehigh Valley R. R. exposes red sandstone and shale dipping 20° (north).

Description of the Lehigh valley.

From White Haven southward, for six miles of a nearly straight course (only broken by one offset to the east below the Lehigh Tannery, about a mile long) the Lehigh river runs through Mauch Chunk red shale rocks, across shallow basins, which are the eastern prolongations of the Green mountain, Little Black creek, Big Black creek, Hazleton, and Drake creek anthracite coal basins on the highland to the west. These synclinals and the anticlinals which separate them all run on eastward, through northern Snyder, into Monroe county; rising as they go, and spreading a thin sheet of red shale of the great Pocono mountain plateau, over which the headwaters of the Lehigh flow at an elevation of 2000′ above tide.

From White Haven to the mouth of the Sandy run (coming in from the west) is 3½ miles (in a straight line); then to Hickory run (from the east) ¾ mile; to Leslie's run (from the west) 1 mile; to Mud run (from the east) 1 mile. Sections were made at Sandy, Leslie's, and Mud runs, which will be given further on.

The river begins its extraordinary meander, in the shape of a flattened letter S, where Mud run enters it, descending from the Pocono plateau through a deep ravine between cliffs of red shale. Mud run follows in fact the red shale eastern continuation of the Beaver Meadow coal basin.

The river receives Mud run and immediately turns sharply west and follows the course which the run would have taken if continued down the basin. It follows this west course 2½ miles to Rockport, where Laurel creek comes in from the west. Here the river makes the Oxbow and doubles back (east) 2 miles, to the mouth of Drakes run, which descends (like Mud run) from the Pocono plateau.

The river here makes a right angle, resuming its proper course for a mile and a half, to and a little beyond Stony creek, which (like Mud and Drakes runs) descends from the Pocono plateau.

The river here repeats almost exactly its behavior at Mud run: that is, it turns sharply west (running in fact at first a little back) and runs 2½ miles, to Penn Haven Junction, at the mouth of Quakake creek.

The river, therefore, by these manœuvers adopts three times a branch (east and west) channel, along the strike, and in a synclinal, in preference to its proper transverse course, from north to south, across the anticlinals and synclinals: first flowing with Mud run westward; then flowing with Laurel creek eastward to Drakes run; lastly, abandoning Drakes run, cutting through the Bald Ridge anticlinal (which is merely a western prong of the great Pocono plateau), to flow with Stony creek back (west) to the Quakake, as if it meant to continue up the Quakake red shale valley, along the northern foot of the Nesquehoning mountain (which is also nothing but a huge projecting of the Pocono plateau); but instead of doing so, it turns south and cuts square across the compound anticlinal mass, between walls of nearly horizontal Catskill strata No. IX, a thousand feet high, making one of the finest gorges in the State; the highland plateau on each side of the gorge being of Pocono strata No. X.

The Quakake Valley red shale (No. XI) runs west and spreads out as Locust valley; surrounds the west end of Nesquehoning mountain and returns east, as Nesquehoning valley to make the kettle at Mauch Chunk.

The sections exhibited at the best points along the river between White Haven and Rockport will now be given.

5 bis. Leslie's run section.

For. No. XI Mauch Chunk red shale.

1.	Red shale,	20′	20′
2.	Shale, green, fissile,	18′	38′
3.	Sandstone, greenish gray, hard, silicious,	10′	48′
4.	Shale, green,	3′	51′
5.	Shale, red, hard,	10′	61
6.	Shale, bluish red,	2′	63′
7.	Shale, red, fissile,	27′	90′
8.	Sandstone, greenish gray, shaly,	25′	115′
9.	Shales, yellowish green,	10′	125′
10.	Shale, red, fissile,	15′	140′
11.	Shale, green,	12′	152′
12.	Shale, red and green variegated,	12′	164′
13.	Shales, purplish and yellow.		

Notes on the above section.

The alternations of strata in the lower part of the formation, No. XI, are well shown near the old canal lock below *Leslie's run.*

At *Mud run* the river bends sharply and flows west, nearly 3 miles, to Rockport. For the first half mile lower XI and upper X rocks are exposed along the L. & S. R. R., dipping about 15° (N.). Then for half a mile, are almost continuous exposures of upper X (Pocono), hard, ocherous sandstone (dipping 15° to 20° (N.) underlying red shale; and rising in a cliff to 50 feet above the railroad, and showing in the river bed.

Near the northern mouth of the Lehigh Valley R. R. tunnel the river, bending slightly, cuts into the overlying red shales, which are continuously exposed as far as *Laurel creek.*

Opposite the tunnel, the river flowing round a bend, crosses the axis of a small synclinal twice—first northwards and then southwards; so as to deceive the spectator with an appearance of a north and south anticlinal with east and west dips.

The axis line of this next synclinal is about 2000′ north of Laurel creek; probably the continuation of one of the small red shale basins north of Mud run. South of the synclinal axis the rocks dips again 15° to 20° (N. W.)

From *Rockport station* on the Lehigh Valley R. R., southwards, are seen first (in a rock cut) red shales and sandstones, underlaid by gray and greenish sandstones, for not much over 600 feet; no doubt, the top rocks of the Pocono No. X.

Round the ox-bow bend of the river, scattered outcrops, with ill-defined dips, occur for more than half a mile nearly to the south end of the Lehigh Valley R. R. tunnel. Here hard gray sandstone overlies a finer greenish sandstone; the south end of the tunnel being seemingly near the axis line of a flat anticlinal.

South of the tunnel, say 500′, a bed of yellow *ochre* is exposed along the railroad for a quarter of a mile (south-easterly) shows the nearly flat stratification of this part of the section.

From the *ochre bed* eastward for nearly a mile and a half to *Drake's creek*, are a number of exposures of gray sandstone, much obscured by cleavage planes, and therefore unsatisfactory, the railroad and river following the strike lines very nearly; but at *Drake's* creek the rocks crop out boldly, *rising* at an angle of 20° (southward.)

The above facts lead to the conclusion that the rocks exposed along the river between *Mud run* and *Rockport*, with north dips, arch over towards the south in a flat anticlinal whose axis passes near the south end of the Rockport tunnel; then they flatten into a shallow synclinal across which the *ochre bed* is exposed; and finally rise again in the north dipping rocks at *Drake's creek*. This conclusion is further substantiated by the fact that the extreme north end of the tunnel passes through a yellow *ochre bed* with a north dip which is doubtless the continuation of that exposed south of the tunnel.

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6. Drake's run section.

For. No. X, Pocono gray sandstone.

1. Sandstone and conglomerale, gray,		126′	126′
2. (Same as 1),	Concealed,	93′	219′
3. Conglomerate, fine, silicious,		213′	432′

4.	Sandstone and shales, dark gray,	51	483
5.	Concealed,	27	510
6.	Shale, yellow, ochrey,	13′	523
7.	Shale, hard,	13′	536
8.	Conglomerate and sandstone, dark gray,	13′	549
9.	Concealed,	76′	625′
10.	Sandstone, greenish gray, dark, hard,	77′	702′
11.	Conglomerate and sandstone, gray silicious,	20′	722′
12.	Shale, green, hard,	27′	749′
13.	Sandstone, gray, hard,	49′	798′

For. No. IX, Catskill shales and sandstones, (444′ exposed.)

14.	Shale, red,	25′	823′
15.	Sandstone, red, hard,	24′	847′
16.	Sandstone, green, hard,	33′	880′
17.	Shale, red,	56′	936′
18.	Sandstone, greenish gray, hard,	36′	972′
19.	Shale, red,	10′	982′
20.	Sandstone, red, hard,	25′	1007′
21.	Sandstone, green and gray,	38′	1045′
22.	Shales, yellowish and red,	78′	1123′
23.	Shale, green,	10′	1133′
24.	Shale, red,	9′	1142′
25.	Sandstone, red,	9′	1151′
26.	Shale, red,	6′	1157′
27.	Sandstone, grayish green, dark,	12′	1169′
28.	Shale, red,	10′	1179′
29.	Shale, greenish gray, hard,	18′	1197′
30.	Shale, red,	25′	1222′
31.	Shale, greenish gray, hard,	20′	1242′

Notes on the above Section 6.

From a point about 500′ north of Drake's run, past the mouth of the run, southward, for nearly a mile, a continuous succession of (N. dipping) hard gray Pocono (X) strata rise from the river bed; and then, underneath them come up the upper Catskill (IX) shales and sandstones; as shown in the section.

(31.) The greenish shale at the base of the section is exposed about 1000′ north of the 118th mile post. For the next 500′ or 600′ the rocks are thrown into several anticlinal and synclinal waves which are well exhibited on the west

bank of the river. Stratum (31) is traceable through all these undulations; and is seen on the south side of the last wave dipping southwards, succeeded by red and greenish shale, overlaid by 'gray silicious sandstones and conglomerate, with a dip of 30° increasing to 60° (S.)

7. Stony Creek section.

For. No. X, Pocono gray sandstone.

1. Conglomerate, gray, silicious, ...	20′	20′
2. Sandstone and conglomerate, gray, silicious, . .	100′	120′
3. Shales, greenish, ...	165′	285′
4. Sandstone, greenish gray, ...	8′	293′
5. Sandstone and dark shales, ...	9′	302′
6. *Shale, black, coaly, (Pocono coal),*	1′	303
7. Sandstone, dark gray, hard, ...	20′	323′
8. Shales, dark, ...	7′	330′
9. Sandstone, dark, shaly, ...	17′	347′
10. Sandstone and shales, greenish gray, silicious, .	87′	434′
11. Concealed, ...	80′	514′
12. Sandstone, greenish gray, hard, silicious, . . .	34′	548′
No. IX. Catskill shales and sandstone, (459′ exposed.)		
13. Sandstone and shale, red, ...	107′	655′
14. Concealed, ...	60′	715′
15. Sandstone, greenish gray, silicious, ...	35′	750′
16. Shale, red, ...	102′	852′
17. Sandstone, greenish gray, hard, ...	50′	902′
18. Shale, red, ...	50′	952′
19. Shale, green, ...	5′	957′
20. Shale, red, ...	15′	972′
21. Shale, greenish gray, hard, ...	35′	1007′

Notes on the above Section 7.

About 600′ north of Stony creek the strata flatten to 30° (S.); then abruptly become horizontal; then take a 5° to 10° dip (N.) which continues to where the river bends west. The section is made of the *south dips* from the synclinal axis northward to stratum (31) of the preceding section 6.

The thickness of Catskill (IX), in the two sections is about the same.

(21) of this section is (31) of the preceding.

(6) of this section does not appear in the other section. It is notable as the nearest approximation to a *Pocono* (X) *coal bed* noticed in this survey by Mr. Winslow.*

*It is a coaly black slate, squeezed and crushed, outcropping at the old canal lock (below mile post 117, L. V. R. R.) along the L. & S. R. R.

The river, south of Stony creek mouth, flows through these rocks about 1,000′. Then bending upon itself northward, it cuts through these rocks again for more than 2,000 feet, until it reaches the axis of the synclinal described above as crossing the Lehigh river a few hundred feet north of *Stony creek*. Here the river bends west and flows in that direction along the axis of the synclinal, to near *Penn Haven Junction.*

Along the north bank of the river the south dips range from 45° to 60°; on the south bank, north dips are not more than 20°; with one or two minor contortions. Along almost the whole length of this westward course, the river bed is cut in Pocono rocks.

Coal. At the old canal lock, below the 117th mile post on the Lehigh Valley R. R., the *black coaly shale* (6) is exposed along the Lehigh and Susquehanna railroad, in a very much squeezed and broken condition.

With the depression of the synclinal axis westwards the river gradually cuts through higher and higher Pocono rocks. Near the bend which it makes a little to the north of Penn Haven Junction it gets up into red shale (XI)*; leaves the axis of the synclinal; and then cuts through *north* dipping Pocono sandstone strata southward for more than half a mile below Penn Haven Junction.

Bald ridge, rises rapidly just south of Rockport to an elevation of about 1300′ A. T. and then, with a more gentle slope, for half a mile or so, to over 1400′ A. T. Beyond this the mountain makes a steep descent of more than 200 feet and, after flattening into a shallow valley or table land, some 1600 or more feet across, it ends precipitously at Quakake creek. A bold anticlinal of Pocono (X) sandstones and conglomerates form the greater part of this ridge; but Mauch Chunk (XI) rocks extend up for some distance on its north side; and on the south, the shallow valley, above spoken of, is underlaid by a synclinal of Lower Mauch Chunk (XI) shales and sandstones.

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* A yellow *ochre bed*, about 8′ thick was cut in the red shale.

8. *Quakake Creek section.*

Measured from the ravine north of Quakake Creek (southward) to the Switch House below the old Railroad Junction.

For. No. XI, Mauch Chunk red shale.

1. Shale, red, with mottled green calcarerous band,	66	66′

For. No. X, Pocono sandstone.

2. Shale, green, hard,	20′	86′
3. Sandstone, gray, silicious,	15′	101′
4. Shales, green,	20′	121′
5. Sandstone, grayish red,	10′	131′
6. Sandstone, greenish gray, hard,	40′	171′
7. Sandstone, gray, hard, silicious, with pebbles,	146′	317′
8. Shales, green,	36′	353′
9. Shales, yellow ochrey,	20′	373′
10. Sandstones and shales, green,	296′	669′
11. Sandstone and shale, red,	25′	694′
12. Sandstones and shales,	205′	899′

For. No. IX, Catskill shales and sandstones.

13. Sandstone and shales, red,	165′	1064′
14. Sandstone, green, shaly,	25′	1089′
15. Shale, red,	44′	1133
16. Shale, green,	15′	1148′
17. Shale and sandstone, red,	15′	1163′
18. Shale and sandstone, green,	44′	1207′
19. Shales, red and green, mottled,	60′	1267′
20. Shales, green,	50′	1317′
21. Concealed,	50′	1367′
22. Shale, greenish gray,	40′	1407′
23. Sandstone and shale, greenish gray,	29′	1436′
24. Sandstone, reddish, conglomeritic with fine quartz pebbles,	63′	1499

Notes on the above Section 8.

Quakake valley is between Bald ridge on the north and Nesquehoning mountain on the south. The valley is here only a few hundred feet in breadth and is nothing more than a channel which the creek has carved for itself out of the rocks. It is formed of Upper Pocono (X) and Lower Mauch Chunk (XI) rocks, dipping northwards.

Strata (1) to (20) are exposed (with continuous north dips of about 30°) to within 1200 feet of where the old Lehigh Valley R. R. bridge crossed the river. There the rocks flatten into a horizontal position and continue thus (with one or two gentle undulations) down to the *old Penn Haven Railroad Junction* where strata (22) to (24) are successively exposed, with gentle north dips.

Succeeding this, within a distance of 1000 feet, stratum (24) is bent by two anticlinal rolls, separated by a shallow synclinal; and then takes a south dip of about 15°. Overlying rocks of the same dip, are then exposed for about 2000 feet, when a synclinal axis is reached. These south dipping rocks are exhibited in the following Section 9.

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9. Mile-post 113 section.

Along the L. V. RR. from the synclinal south of Mile-post 113, measured northward.

For. No. IX, Catskill red sandstone and shale.

1.	Shale, red,	35′	35′
2.	Shale, green,	9′	44′
3.	Concealed (in ravine),	51′	95′
4.	Shale, green,	10′	105′
5.	Shales, red,	61′	166′
6.	Sandstone, hard, gray, pebbly,	13′	179′
7.	Shale, green,	7′	186
8.	Shale, red,	10′	196′
9.	Sandstone, shale and slate, green,	42′	238′
10.	Sandstone, red, conglomerate,	20′	258′
11.	Sandstone and shales, gray, green and reddish,	133′	391′
12.	Sandstone, chocolate red, hard,	56′	447′

Notes on the above Section 9.

Stratum (12) of this section is the same as (24) of Section 8. It dips beneath the surface a little to the south of the *Switch House hut*, rising again (on the south side of the synclinal) at a point on the railroad about 2400 feet north of the junction of *Little Bear creek* with the Lehigh river.

From this point southwards to *Little Bear creek* the strata, though thrown into a number of rolls, some sharp and on others gentle, lie in a general way horizontal. Stratum (12) is frequently exposed in ledges; but about opposite the mouth of the creek it disappears with a dip of about 10° (S.).

Around the curve of the river, below *Little Bear creek*, a series of red and green south-dipping rocks are exposed; but the river, gradually bending around to the north-west, gradually gets into the line of strike, and then (bending still more) begins to cut back across the strata northward; soon however, making a sharp reverse bend just north of Mile-post 111, it cuts once more across the same south-dipping strata, southward.

Within 1000 feet south of the Mile-post 111 the rocks change from their south dips of about 15° to north dips of about 20°, making a synclinal, which is well exposed along the river, and also higher up on the side of *Kettle mountain*.

10. Little Bear Creek section.

From L. Bear creek, southward, along the L. V. RR. to the synclinal axis south of Mile-post 111.

For. No. IX, Catskill red SS. and shale.

1.	Conglomerate, greenish gray, fine,	30′	30′
2.	Sandstone, greenish and chocolate gray, hard,	68′	98′
3.	Sandstone, green,	36′	134′
4.	Sandstone and shale, red,	88′	222′
5.	Slate or shale, green,	7′	229′
6.	Sandstone, red,	7′	236′
7.	Sandstone and shale, green,	39′	275′
8.	Sandstone and shale, red,	32′	307′
9.	Concealed,	37′	344′
10.	Sandstone and shale, green,	33′	377′
11.	Sandstone, shaly, red,	6′	383′
12.	Sandstone, dark greenish gray, shaly,	15′	398′
13.	Sandstone, gray, silicious,	8′	406′
14.	Shale, red,	22′	428′
15.	Sandstone, reddish gray, coarse, with pebbles,	71′	499
16.	Sandstone, red, shaly,	13′	512′
17.	Shales, green,	63′	575′
18.	Shales, red and green,	38′	613′
19.	Sandstone, pink, reddish gray (= 22 of Sect. 9),	10′	623′

Notes on the above Section 10.

Kettle mountain is the same as Nesquehoning mountain; the river having cut a trench through and across the Pocono anticlinal. Little Bear creek flows in a ravine of red shale down the synclinal to the river. Kettle mountain, south of the ravine, joins Pocono mountain north of the ravine on the highland of N. E. Carbon county. The cliffs of the ravine are 400′ high, and above the cliffs gentle slopes rise to 1000′ above the river.

(1) to (14) of the section were measured in a continuous exposure northwards from the axis of the synclinal; but between (14) and (15) there intervenes, along the northward curving of the river, about half a mile, with only one small exposure of red shale. Stratum (15) crops out with a south dip of 17° about 500 feet south of the 112th mile post opposite *Little Bear creek.* It is placed in the section in what is regarded as its true stratigraphical position.

(19) of this section is the same as (12) of the preceding section 9. It is exposed a little north of the creek.

From the synclinal southward the rocks rise (at 20°) for nearly 1000′; then flatten; then, at the west end of the river bend, undulate nearly horizontally; then, around the curve, past mile-post 110, dip south; but surface trash, and the line of strike make the amount of dip uncertain; it is probably flat for 1000′.

South of the house on the curve below the 110th mile-post, a ledge of grayish green sandstone is exposed along the railroad, for more than 800′, nearly horizontal, but somewhat undulating, and with a general slight south dip.

From this last exposure we pass southwards through a long series of south dipping rocks for more than two miles to *East Mauch Chunk* where, at an old dam, just south of the 107th mile-post, about 1800 feet north of the bridge over the river, the synclinal axis of the Kettle (or of the Panther creek coal basin,) is reached, and here, in the south dipping rocks of the north side of the synclinal the next section was made.

11. Glen Onoko section.

Measured (along the L. V. R. R.) from a point 1800′ N. of East Mauch Chunk bridge, northward, to a point about 3000′ N. of Glen Onoko.

For. No. XI, Mauch Chunk red shale.

1. Red sandstone and shale, ...	1367′	1367′
2. Partially concealed (sandstone and shale, red and green), ...	608′	1975′

For. No. X, Pocono gray sandstone.

3. Sandstone, gray, hard, silicious, ...	160′	2135′
4. Sandstone with shale, dark gray, ...	118′	2253′
5. Sandstone, gray silicious, quartz pebbles, ...	305′	2558
6. Conglomerate, silicious medium, ...	25′	2583′
7. Concealed (greenish gray sandstone), ...	252′	2835′
8. Sandstone, gray, ...	84′	2919′
9. Concealed, ...	279′	3198′

For. No. XI, Catskill red sandstone.

10. Shale, red, ...	57′	3255′
11. Sandstone and shale, greenish gray, ...	31′	3286′
12. Sandstone, red shaly, ...	23′	3309′
13. Sandstone, greenish gray, hard; with shale, . .	28′	3337′
14. Sandstone, gray, fine, hard, ...	15′	3352′
15. Sandstone, greenish gray, shaly, ...	28′	3380′
16. Sandstone, greenish gray, ...	50′	3430′

Notes on the above section 11.

Kettle valley, east of Mauch Chunk, is a synclinal valley underlaid chiefly by Mauch Chunk red shale XI. Geologically it is the eastern continuation of the Southern coal basin whose eastern extremity is marked by Mount Pisgah, while topographically it is formed by the coalescense of Nesquehoning and Bloomingdale valleys which border the coal basin on the north and south.

The strata included in (1), exposed along the east bank of the river, above the railroads, from the synclinal axis to about a quarter of a mile north of the Lehigh Valley R. R. bridge at *Coal Port*, are alternate red sandstones and soft red shales.

The dips (a little east of south in direction) vary between 20° and 45°, with an average of about 30°.

Ripple marks. The shales are, in places, abundantly covered with *ripple marks*, *with the steep side towards the south.*

The area underlaid by (2) is included between the north end of (1) and the outcrop at the Lehigh and Susquehanna R. R. tunnel near *Glen Onoko.* On the the east bank of the river this area is covered by detritus; but, on the west bank, above Nesquehoning creek, are occasional exposures of red and green or gray sandstone beds.

Strata (3) to (6) are exposed from the south side of *Glen Onoko*, northward, to about 500 feet north of the *Signal house*, between the Lehigh Valley and Lehigh and Susquehanna railroads. The average dip is somewhat more than 30° S. S. E.

Stratum (8) is exposed about 500 feet north of the last and has a dip of about 50° (S. S. E.)

The remaining strata of the section are exposed within the next 1200 feet and have a general dip of about 20° (southwards).

The strata south from the synclinal axis above *East Mauch Chunk* assume within a few hundred feet, a north dip of about 40°; which steadily increases; until, near the turntable, at the Lehigh Valley R. R. station, at *East Mauch Chunk*, it is 60°; and, about 1000 feet further on, 90° (vertical). Rocks with these steep north dips are continuously exposed from *Mauch Chunk* southwards, around the spur of *Bear mountain*, past *Packerton*, down to the vicinity of *Lock No. 7*, a mile above Weissport. This furnishes the long Mauch Chunk Section, reported by the First Geological Survey*; by Prof. I. C. White†; and now by Mr. Winslow.

*See Geol. Penn. 1858. † Report G 6, p. 187.

12. Mauch Chunk section.

Compiled from measurements on Mt. Pisgah, at Mauch Chunk, through Bear Mountain (Second mountain) gap, and down the Lehigh river, past Packerton, to Canal Lock No. 7, above Weissport.

For. No. XII, Pottsville conglomerate (thickness 1000′).

1. Conglomerate and sandstone, silicious;	820′	820′
2. Shale, red, ...	60′	880′
3. Conglomerate, green, with large quartz pebbles,	120′	1000′

(For. No. XI, Mauch Chunk red shale thickness 2168′).

4. Shales and sandstones, red, ...	1662′	2662′
5. Sandstone, yellow, friable, ...	83′	2745′
6. Shale, red, ...	28′	2773′
7. Sandstone, chocolate gray, hard, ...	28′	2801′
8. (Shales ?) mostly concealed, ...	367′	3168,

For. No. X, Pocono gray sandstone (thickness 1253′).

9. Sandstones, gray, hard, ...	25′	3193
10. (Sandstones, gray, with conglom.?)	309′	3502′
11. Sandstone, gray, hard, ...	46′	3548′
12. Conglomerate with sandstone, medium. silicious,	60′	3608′
13. Shale and slate, dark, ...	20′	3628′
14. Sandstone, grayish, coarse, ...	26′	3654′
15. Slate, dark, ...	13′	3667′
16. Sandstone with pebbles, dark gray, silicious, .	50′	3717′
17. Conglomerate, coarse, silicious, ...	14′	3731′
18. Shale and sandstone, grayish green, ...	28′	3759′
19. Ochre, yellow, ...	5′	3764′
20. Shale, greenish, ...	13′	3777′
21. Ochre, yellow, ...	5′	3782′
22. Shales, olive green, ochery, ...	55′	3837′
23. Sandstone with shale, and slate dark gray, . .	282′	4119′
24. SS. white, fine, hard, (with soapstone layer at bottom), ...	48′	4167′
25. Shales, dark, greenish and varigated, ...	40′	4207′
26. Sandstone, dark, gray and reddish, hard; with few large, very widely scattered pebbles), . .	214′	4421′

For. No. IX, Catskill red SS., &c. (thickness 7145′).

27. Sandstone, red, hard, with vitrious quartz grains,	32′	4453′
28. Shale, ochery, ...	9′	4462′
29. Sandstone, grayish green, ...	27′	4489′

30. Shale, red,	18′	4507′
31. Sandstone, shaly, light green, fine,	5′	4512′
32. Shale, red,	9′	4521′
33. Sandstone, red, hard,	72′	4593′
34. Sandstone, red, hard,	30′	4624′
35. Slates and shales, green,	30′	4653′
36. Shales and sandstone, red,	49′	4702′
37. Sandstone, greenish gray,	19′	4721′
38. Shale, red,	202′	4923′
39. Sandstone, green,	10	4933′
40. Sandstone, red and greenish gray (with pebbles),	49′	4982′
41. Shale red,	19′	5001′
42. Sandstone, chocolate gray (with quartz pebbles),	44′	5045′
43. Sandstone and shale, red,	70′	5115′
44. Sandstone, reddish brown, hard, coarse (with quartz pebbles, scattered, and in bands),	147′	5262′
45. Shale, greenish gray, (with scattered pebbles),	106′	5368′
46. Sandstone, conglomeratic, chocolate red, (with quartz pebbles),	12′	5380′
47. Sandstone, greenish gray, hard, flaggy, (with quartz pebbles, scattered and in thin bands),	516′	5896′
48. Sandstone, red,	11′	5907′
49. Flaggy sandstone like 47,	547′	6454′
50. Sandstone, greenish gray, fine, with shale,	526′	6980
51. Sandstone, red, shaly,	47′	7027′
52. Sandstone and shale, greenish,	160′	7187′
53. Sandstone and shale, reddish,	37′	7224′
54. Sandstone, grayish green,	113′	7337
55. Shale, red,	57′	7394′
56. Sandstone, greenish gray, silicious,	225′	7619′
57. Shale, red,	19′	7638′
58. Sandstone and shale, greenish,	111′	7749′
59. Sandstone and shale, reddish,	37′	7786′
60. Sandstone and shale, greenish,	19′	7805′
61. Sandstone and shale, red, (with *calcareous band*)	56′	7861′
62. Sandstone, greenish gray,	37′	7898′
63. Shale, red,	92′	7990′
64. Sandstone, greenish gray.	139′	8129′
65. Sandstone and shale, red,	19′	8148′
66. Shale, green,	37	8185′
67. Shale, red,	92′	8277′
68. Sandstone, green,	46′	8323′
69. Shale, red,	307′	8630′
70. Shales, red and green, variegated,	84′	8714′
71. Shales, red,	310′	9024′
72. Sandstones and shale, greenish gray,	20′	9044
73. Shales, red,	105′	9149′
74. Shales, green,	15′	9164′
75. Shales, red,	25′	9189′
76. Shales, green,	20′	9209′
77. Shales, red,	60′	9269′
78. Shales, grayish green,	42′	9311′

79. Shale, red with thin green bands,	548′	9859′
80. Sandstone, greenish gray,	110′	9969′
81. Sandstones, red,	6′	9975′
82. Sandstones, greenish gray,	15′	9990′
83. Sandstone, red,	5′	9995′
84. Sandstones, greenish gray,	1155′	11150′
85. Shales, red and green,	104′	11254′
86. Shales, red, (some green),	312′	11566′

For. No. VIII, g, f, Chemung and Portage (thickness 1292).

87. Shales and slate, dark and hard, flaggy sandstone,	700′	12266′
88. Shales, dark, fissile, with little sandstone,	592′	12858′

For. No. VIII, e, Genesee shales.

89. Shales, black, fissile, much broken, (visible),	290′	13148′

Notes to the above Section 12.

The horizontal length of this remarkable section line, measured across the nearly vertical outcrops, from the synclinal axis in the Mauch Chunk Kettle, south, to the great Mahoning valley anticlinal axis, between Packerton and Weissport, is 2¼ miles, or about 12,000 feet.

Mt. Pisgah, at which the top of the section starts, is the east point of the Panther Creek coal basin,* capped by Pottsville conglomerate No. XII, overlooking Mauch Chunk from the north. But a part of No. XII only is preserved. The thickness of the formation is therefore taken from the Hacklebarney Tunnel section (Report AA) two miles further west.

(1.) On Mount Pisgah are seen alternations of conglomerate, sandstone and shale.

(2.) Red shale crops out immediately above (3) conglomerate along the wagon road to Nesquehoning at the base of Mt. Pisgah opposite the L. & S. R. R. coal chutes.

(3) Is a greenish rock, holding milk white quartz pebbles,

*The eastern division of the southern (Tamaqua and Pottsville) Anthracite coal field.

and also a few *pebbles of green sandstone;* it has interbedded in it beds of green sandstone; which may possibly be the greenish sandstone in the upper part of XI near White Haven.

(8, 9) The base of XI strikes across the L. V. R. R. within 1000′ south of East Mauch Chunk R. R. station, through the center of Mauch Chunk, rising on the side of Mahoning mountain behind the public school.

(9 to 26) The Pocono strata (X) crop out along the L. V. R. R. southward to within 100′ of the Mauch Chunk R. R. station; making Bear mountain (the Second mountain of Schuylkill county.)

(27 to 33). The Upper Catskill strata* (IX) are exposed along the L. V. R. R. in the gap, southward, to about 100′ south of mile-post 106 at the railroad station, where the river turns to flow east in the heart of the mountain, but still cutting diagonally deeper and deeper into the formation.

(34 to 46) Soft Catskill strata were measured along the L. & S. R. R. on the west bank of the river.

(44) The reddish pebbly sandstone is well exposed at the north end of the L. V. R. R. bridge (a mile north of Packerton) just where the river turns south to cut through the southern half of the mountain. It resembles (24) of section 8 at Quakake creek, and (12) of section 9, exposed along the river near Little Bear creek. Prof. White's section (Report G. 6) identifies it (theoretically) with the *Cherry Ridge conglomerate* of Susquehanna, Wayne and Pike counties.

(46) is exposed a little south of (44) on the L. & S. R. R.

(47). The upper beds are exposed for about 200′, and then everything is concealed for 1000′ further south, where the lower beds of (47) appear.

(48, 49) were measured along the canal on the east bank of the river.

(50 to 71) are continuously exposed along the L. & S. RR. from 1500′ south of mile-post 105 (L. V. RR.) to within

*It is a question of nomenclature whether part of these massive rocks should not still be considered Pocono (X) as they were by the First Survey.

200′ of the small bridge over the gully opposite the L. V. RR. office buildings in Packertown.

(71 to 89) were measured along the canal from Lock 6 to Lock 7; but they are also well exposed along the two railroads on the opposite (west) bank; especially (79) in the L & S. RR. rock cut.

(86) adopted as the base of the *Catskill formation* (IX) crops out about 1000′ south of the foot bridge over the canal at Long run.

(87, 88) are imperfectly exposed; but evidently belong to the *Chemung* and perhaps *Portage formations* (VIII*g*. and VIII*f*.) The lower limit cannot be well defined; but it must come somewhere about 1000′ north of Lock 7.

(89) can safely be called *Genesee* (VIII*e*.) dipping, like all the previous, overlying formations 80° and more northward. The great Mahoning Valley anticlinal axis crosses the river near Lock 7; and then the *Genesee*, *Portage* (?), *Chemung*, and lower *Catskill* descend with a gentle south dip into the Wire Ridge synclinal; to rise again, with steep dips, at Bowmansville.

Formations IX, X.

Bear mountain (Second mountain) has two well defined, sharp, parallel crests,* about 1200′ apart, separated by a shallow trench. This character it maintains all the way west to the Little Schuylkill river at Tamaqua, and for several miles further. The same character marks it for many miles east and west of Pottsville. The rock strata stand vertical, or nearly so, and the two crests are made by excessively hard sandstone beds; but the northern crest is of gray sandstone (*Pocono, X*); the southern crest of red sandstone (*Catskill, IX.*) The *Pocono gray rocks* extend from the northern crest down the northern slope to the bottom layers of the red shale XI; and the *Catskill red rocks* extend from the southern crest down the southern slope and across a terrace, or sometimes a smaller mountain (often called Little mountain) to the top layers of the *Chemung formation* (*VIII*) in the Mahoning valley.

* This does not appear in the section on the sheets.

Between the two crests runs the groove, about 1200′ wide, of soft alternating gray and red rocks, mostly shales, but with many beds of sandstone not massive. In this intermediate series the river Lehigh has cut its bend in the gap below Mauch Chunk.

The First Survey drew the dividing line between formations X and IX along the middle of this groove, adding the upper half of the 1200′ of soft rocks to the bottom of X, and the lower half of them to the top of IX. The fact is, no dividing line between the two formations can be found; and all that can be said is that the *Catskill* red deposits (IX) gradually became more and more gray until the whole become *Pocono* (X.)

Prof. White, however, having made a classification of the two formations in his survey of the north-eastern counties, when he desired to compare their character and size on the Lehigh with their character and size on the Upper Delaware, was obliged to include not only the whole soft 1200′ of the groove, but also the northern gray crest in his Catskill formation; greatly increasing the thickness of IX, and diminishing by that much the thickness of X.*

The natural arrangement would be to call the 1200′ soft rocks in the groove (in the river bend) *transition beds of IX to X*. But there can be no good reason assigned against making them the uppermost subdivision of IX; and starting X with the northern grey crest rocks. This in fact has been done in publishing Prof. White's Lehigh section, on page 79, Report G. 6 1882.†

Lehigh river section by I. C. White.

1. Light gray massive conglomerate, large pebbles,	50′	750′
2. Greenish gray sandy shales, ...	50′	
3. Dark gray conglomerate, with coaly streaks, . .	50′	
4. Buff gray sandy shales, ...	120′	
5. Dark buff sandstone, with some shales, ...	430′	
6. *Mt. Pleasant Conglomerate* (*north crest*), . . .	50′	

* This was because, in carrying his Wayne County formations through Pike into Monroe, be found that his top Catskill conglomerate formed the brow of the Pocono plateau. But it was this very Conglomerate brow that had given the name *Pocono* to the overlying formation; and in the First Survey (1839) I traced the brow conglomerate west to the Lehigh and found it to be the northern crest of Bear mountain.—J. P. L.

† By my direction.—J. P. L.

7. *Mt. Pleasant*,	*red shale*,	40'	700'
	red sandstone,	40'	
	red and green shale,	60'	
	red conglomerate,	10'	
	red shale,	250'	
	red shale and sandstone,	100'	
8.	Reddish sandstone and shales,	200'	
9.	*Cherry ridge conglomerate*, (south crest),	40'	200'
	" " greenish sandstones,	110'	
	" " conglomerate,	50	
10.	Concealed,		200'
11.	Gray pebbly conglomerate,	60'	707'
12.	Greenish flaggy sandstones,	350'	
13.	Gray sandstones (two or three red beds),	175'	
14.	*Calcareous breccia*,	2'	
15.	Gray massive sandstones (a few thin red),	120'	
16.	*Red sandy shales*,	30'	210'
17.	Greenish gray, very massive sandstone,	120	
18.	*Red sandy shales*,	60'	
19.	Greenish gray, massive SS. (some pebbles),	165'	415'
20.	*Calcareous breccia*,	8'	
21.	Greenish gray sandstone,	180'	
22.	*Calcareous breccia*,	2'	
23.	Greenish gray sandstone,	60'	
24.	*Green and red* beds,	60	90'
25.	*Red sandy shale*,	30'	
26.	*Calcareous breccia*,	2'	62'
27.	Greenish gray massive SS. (some pebbles),	60'	
28.	*Red shales and red sandstones*,	120'	420'
29.	Gray sandstones (with a little red),	150'	
30.	*Red* and greenish gray sandstones,	150'	
31.	*Montrose red shales* (a few thin gray),		2000'
32.	*Delaware gray flags* (no red),		1200'
33.	*Red and gray sandstone and red shales*,		700'
34.	Greenish gray flags (occasional red) say,		600'
35.	*Chemung*, bluish gray and olive sandstones, with some shales, sparingly fossiliferous,		1200'
36.	Genesee shale, dark, fissile,		200'

Thus we have the *Pocono* (X) represented as 750'; the soft rocks between the crests (X–IX) as 700'; the *Catskill*, as 6894'; the *Chemung*, as only 1200'; the *Genesee*, 200'.

In Mr. Winslow's section 12, we have the *Pocono* represented as 1253'; *Catskill*, 7145'; *Chemung*, 1292'; *Genesee*, (visible) 290'.

From top of X to bottom of IX (White),	8344'
From top of X to bottom of IX (Winslow),	8398'

So close a concordance inspires confidence in the general accuracy of the two sections. At the same time there are

some noteworthy differences, most of them to be explained by the different grouping of the smaller subdivisions.

Thus, White's (1) (2) (3) are Winslow's (12 to 17) with differently estimated thickness.

(12)	60′		(1)	50′
(13)	20′			
(14)	26′	59′	(2)	50′
(15)	13′			
(16)	50′	64′	(3)	50′
(17)	14′			
	183′			150′

The "buffish colored" strata* in Prof. White's section, 550′ thick, correspond to Winslow's greenish gray series (18 to 25) which he makes 524′ thick.

The *Mt. Pleasant conglomerate* of Prof. White's section ought to crop out near the L. V. RR. station at Mauch Chunk; but careful search for it on several occasions failed to find any rock of the character described; no *conglomerate* is visible, even in the recent rock cuttings for an additional track, which are very favorable for close observation of the strata. The strata grouped as (26) contain a few large pebbles scattered through them at intervals of a foot or more; but there is not in the whole 214′ a single bed which can be called a conglomerate.

White's red *Mt. Pleasant shale* series, 700′ thick, corresponds well with (27 to 43) 694′ thick.

White's (9) *Cherry Hill conglomerate*, 200′ thick, is Winslow's (44 to 46) 265′ thick, exposed along the L. & S. RR. about 1300′ south of the river wagon bridge opposite the Mansion House in Mauch Chunk, and again partially near the south end of L. V. RR. bridge in the gap, where probably Prof. White's measurement of it was made. The upper member (44) is merely a pebbly sand-

*These *buffish* rocks are *weathered* to that color. A fresh fracture shows that the real color of the rock is greenish or gray. The whole surface of a hard greenish or gray rock is frequently changed to a soft, yellowish brown (and sometimes almost black) color. Angular fragments can be picked up almost anywhere which, when broken open, will show beautifully marked, gradations of color and texture as a result of weathering, from the surface inwards. A hard, compact and seemingly durable rock is thus made soft and friable.

stone, of chocolate red color, with silicious pebbles generally less than half an inch in diameter, and with other *larger pebbles of red shale*, generally scattered, but in some places collected into bands which might be called conglomerate. The middle green member (45) has scattered pebbles through it also. But no third or bottom conglomerate member could be found except one reddish stratum about 8′ thick, largely composed of quartz pebbles (46.)

The next 1600′ of gray and greenish flags overlie about 3000′ of red, green and gray alternations. Prof. White's 600′ of gray and greenish flags overlie more than 3500′ of red, green and gray alternations; which merely indicates a difference in the color-interpretation.

White's (32) agrees remarkably well with Winslow's (84); but there is a considerable difference in the thicknesses assigned to the next underlying red and green shale.

The lower limit of *Catskill No. IX*, has given trouble all over Pennsylvania, and it is everywhere evident that the *Chemung formation* passes insensibly up into *Catskill*, by a series of *transition* beds; more olive than red below, more red than olive above; the fossils also ascending and mixing like the colors.

South of Lock No. 7 the *Genesee shales* are exposed for over a mile to below Lock No. 9 at *Weissport*. Their fissile and broken character is well shown here; in places they are so black that the rock looks more like weathered coal, or highly carbonaceous shale. Though having a general south dip they appear to be thrown into numerous contortions.

Between Locks 9 and 10 the *Chemung flags* again crop out with a dip of about 20° (S. S. E.). They are well exposed in the flagstone quarry behind the Old Brewery at Lock 10. These rocks are continuously exposed almost down to the railroad bridge over the canal above *Parryville*. Here the overlying lower *Catskill* red and green shales are exposed continuously to the furnaces at Parryville.*

*For a description of the formations south of Parryville, see Dr. H. Martyn Chance's Report on the Survey of the Lehigh Water Gap, G⁶.

13. Lehigh River section.

Lehigh River section continued from Lock 11, southward, to the Blue mountain; by Frank A. Hill, Asst. Geol.

The section line in its course to the south crosses the Lehigh river for the last time, about 600 feet south-east of Lock No. 10 of the Lehigh canal below Weissport. After leaving the river there are very few exposures along the immediate line of the section. Along the banks of the river, however, the measures are plainly exposed and the cuttings of the Lehigh Valley R. R. on the west and the Lehigh and Susquehanna R. R. on the east bank, show an almost continuous section to beyond the Lehigh gap in the Blue mountains. Individual strata were found which were readily traced from the river to our section line.

Parryville lies east of the section line 4560′; Bowman's Lehigh Valley R. R. station is east 2940′; the brick-yard at Hazardville is 5460′; Lehigh Gap L. & S. station 17,160′. A large part of our section has been projected for these distances.

Just below Lock No. 11, the red Catskill rocks are exposed on both sides of the river. Their dips vary from horizontal to 12° (S.) gradually steepening; so that at 1000′ below Parryville station they dip 30°. From here the dips increase towards the Wire Ridge synclinal axis, varying between 40° and 62°, the average being probably 52°. The axis of the synclinal basin is plainly shown 1800′ south of Parryville station; the north dip near the axis being 72°. Six hundred feet further south it has flattened to 18°; 50 feet beyond this, a local anticlinal fold is plainly exposed; and 75 feet further a synclinal fold.

It is questionable where the parting between *Catskill No. IX* and *Chemung No. VIII*, should be placed. I have located it 2650′ from the Parryville station, and about opposite the Lehigh and Susquehanna watch box. At this point the lowest *Catskill red bed* outcrops on the north dip of the Wire Ridge basin. From here, for a distance of

1300′, the green and olive *Chemung shales* rise in succession, with north dips varying from 58° to 40°.

The parting between *Chemung* and *Genesee*, at this point, near Lock 14, is plainly exposed.

Only 125 feet of north dipping *Genesee shales* are visible; for here (on the wagon road opposite the dwelling house of the lock-master at Lock No. 14) they arch over a faulted anticlinal, and are quickly lost in the confusion of dips occurring immediately on its southern side.* After leaving this scene of confusion, both as to dips and measures, we pass through generally parallel, and apparently inverted *Hamilton* and *Marcellus* strata, to Stony ridge, or Devil's wall, a boldly defined *Oriskany* hill, with the same inverted dips.

Between Wire ridge and Stony ridge the country is rolling, save where it is deeply cut by the waters of the creek. From the crest of Stony ridge we rapidly descend south through the *Oriskany* shales and the *Lower Helderberg* limestones and shales into the valley of Lizard creek. From here, gradually at first and then more rapidly, we ascend the northern slope of the Blue mountain; and nearing its crest, reach the parting between the *Clinton* red shales No. V and the *Medina* sandstone No. IV.

The average dip of the *Hamilton*, *Marcellus*, *Oriskany* and *Lower Helderberg* is about 75° (south, *i. e.* inverted). The *Clinton* red shales vary from 75° at their junction with No. VI to 90°, and then taking their normal north dip gradually diminish to about 45°, where they join *the Medina sandstone* No. IV.

The dips of the rocks of No. IV vary between 28° to 48° (north).

Formations in the Wire Ridge synclinal.

For. No. IX Catskill.—In the Wire Ridge synclinal only the lower one-sixth of this formation remains. Wherever exposed they are seen to be red sandstones and shales interleaved with green sandstone beds. Towards the bottom the

* Here inverted north dipping *Hamilton* beds override the *Genesee*; the upthrow on the *Hamilton* side of the fault being about 1500′.

green sandstones are more frequent and mark the parting between the bottom of IX and the top of VIII hard to determine.

For. No. VIII g, Chemung.—There are in this formation 745 feet of green and olive shales and sandstones; also, towards the bottom, some hard blue sandy shales resembling somewhat the cement beds which overlie the *Oriskany sandstone* farther down the river.

For. No. VIII e, Genesee shales.—Only 125 feet of these shales are exposed on the north side of the anticlinal fault at Lock No. 14. They are quite like the shales which rise on each side of the anticlinal near Weissport; very dark, fissile and thinly laminated; weathering readily; loose pieces lying scattered abundantly over the slopes below their outcrop.

For. No. VIII c, Hamilton shale.—The formation is here made up of dark gray shale (weathering yellow) devoid of fossils, excepting a mass of dark hard slate, 168′ thick towards the bottom, which is highly fossiliferous. The total thickness of the *Hamilton* is about 1180′.*

For. No. VIII b, Marcellus Black shale.—While there is an exposed thickness of 1370 feet of dark friable shales it is a question whether this is the true thickness of the entire formation. They are so crushed that their dips cannot be determined with any degree of accuracy.

For. No. VIII a, Upper Helderberg.—This formation is not noticeable on the river along the immediate line of section; but east and west of it is developed in the mines of the paint manufacturing companies described in detail further on. The upper part is represented by *hydraulic cement layers* varying from 1 to 50 feet in thickness. These are underlaid by *the metallic paint bed*, which has an average thickness of about 2 feet. This is underlaid by *clay*, varying in thickness from 4 to 10 feet.

For. No. VII. Oriskany sandstone and shale.—There are 480 feet of sandstone beds and underlying shales exposed in Stony ridge. With the exception of a small por-

*This assigned thickness is however doubtful, owing to the confusion of dips, especially at its contact with the Genesee.

tion near the bottom they are beautifully shown in the Rutherford tunnel, on the north side of the ridge, and in tunnel No. 5 of the Prince Manufacturing Company on the south side. The following is a section showing the measures cut in these two tunnels. (See plate, page 1376.)

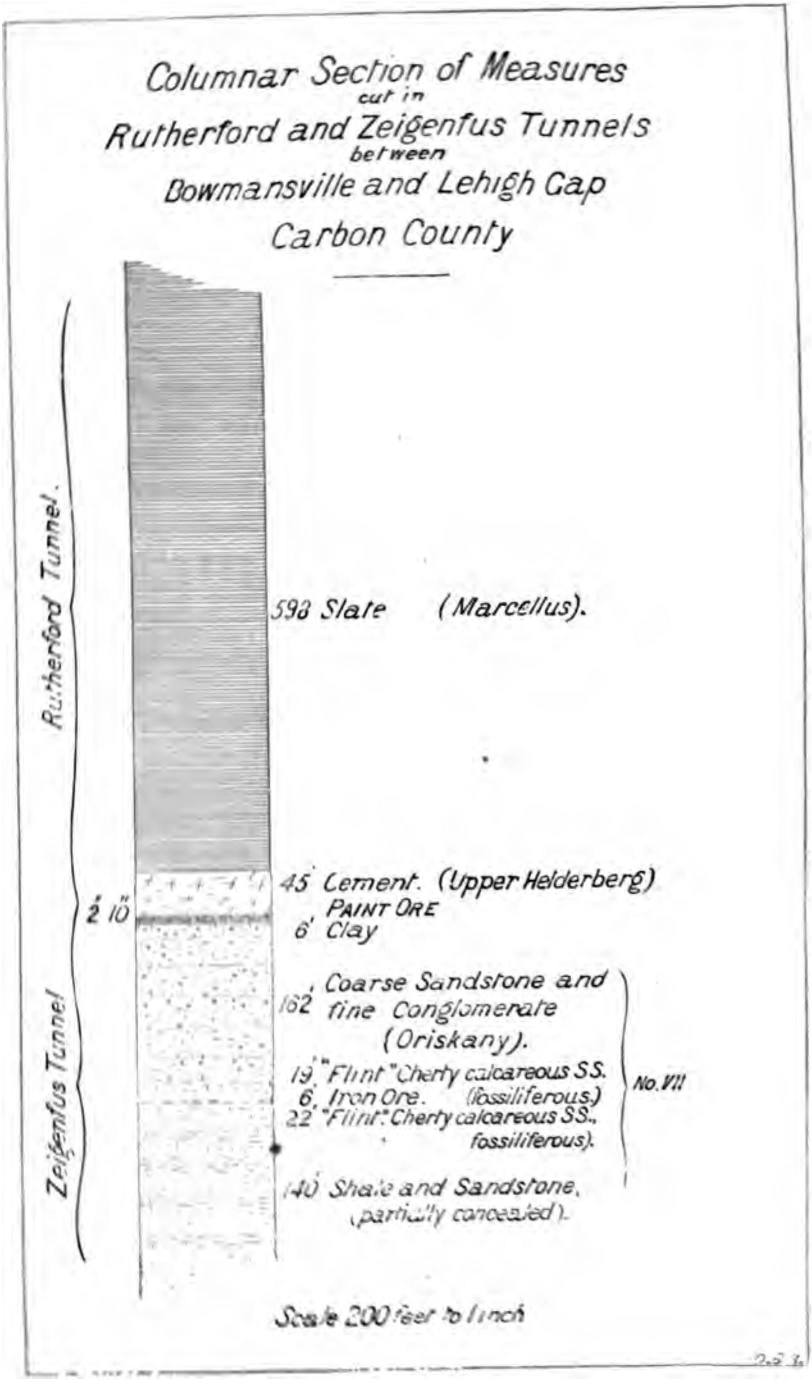
The Oriskany sandstone beds are of varied coarseness, from fine sand to pea conglomerate, held together by a calcareous cement. Along the outcrop the cement has weathered away, and the summit of the hill is a succession of loose deposits of sand, which in places have been extensively quarried, as a series of pits extending for miles along the Stony ridge.

The underlying shales alternate with flint beds of varied thickness. The total thickness of these shales is doubtful, because their contact with the Lower Helderberg No. VI is not exposed. But the curious faulted plications described by Dr. Chance in Report G[6] do not extend west to the line of section, and therefore are not exhibited on the sheets.

For. No. VI, Lower Helderberg limestone.—East and west of our section line this formation occurs along the valleys of Aquanchicola and Lizard Creeks; generally covered by local drift deposits; but partially exposed along the L. & S. R. R. below Bowmansville; and quarried north-east of Hazardville; where are seen green shales 35′; soft slaty limestone 30′; and shales only partially exposed, 125′; about 400 feet of shales and limestone of which the exposures are so few and unsatisfactory as to make any detailed description impossible. The total thickness of the formation is about 600′.

For. No. V. Clinton.—The published section by Dr. Chance in the Lehigh Water gap was verified in all its details and transferred to the south end of our section; the line of which upon the map shows almost nothing of this and the underlying formations.

Clinton Upper red shale.—This is a very soft red shale, with thin beds of olive shale, as on the Delaware and on the Schuylkill rivers, and at what appears to be a corresponding horizon; total exposed thickness, 650′.


Columnar Section of Measures
cut in
Rutherford and Zeigenfus Tunnels
between
Bowmansville and Lehigh Gap
Carbon County
Rutherford Tunnel.
598 Slate (Marcellus).
45' Cement. (Upper Helderberg)
2' 10" PAINT ORE
6' Clay
162' Coarse Sandstone and fine Conglomerate (Oriskany).
19' "Flint" Cherty calcareous SS.
6' Iron Ore. (fossiliferous.)
22' "Flint" Cherty calcareous SS., fossiliferous).
No. VII
140' Shale and Sandstone, (partially concealed).
Zeigenfus Tunnel
Scale 200 feet to 1 inch

Clinton Upper red and olive shales.—These transition beds at the Lehigh are all olive shales, and all red at the Delaware Water gap. Here, on the Lehigh, they become an intermediate subdivision of the Clinton formation; being included in the *Upper olive* shale at the Schuylkill and in the *Upper red* shale at the Delaware. Exposed upon the western side of the river, along the roadway of the Lehigh Valley railroad, it has a thickness of 90′.

Clinton Upper olive shale.—A mass of true olive slaty calcareous shale; poorly exposed upon the eastern side of the river, but well seen on the western bank. Absent at the Delaware, present at the Schuylkill, its thickness at the Lehigh is 120′.

Clinton Ore sandstone.—A hard, compact, greenish-gray sandstone, with thin partings of olive shale; a rather fine-grained mass, with some slightly conglomeratic layers in it. It outcrops along the railroad track above the station; along Aquanchicola creek (where it presents a perpendicular face); and along the track of the Lehigh Valley railroad. It makes the terrace on the north side of the mountain; and the nose which projects southward from the Eddy Hill in the gap, upon which the house of Mr. William Craig stands. Thickness, 125′.

Clinton Lower red and olive shales.—A mass of alternations of sandy red and olive shale, with red sandstone beds; 125′ (more or less) of which is hidden by the Aquanchicola creek, but well exposed in the L. & S. R. R. cuttings. The upper part of the mass is well exposed above the Gap station; the lower portion presents a fine natural exposure back of Craig's hotel. These shales make the terrace on the northern side of the mountain. Thickness, 290′.

For. No. IV e, Medina Upper sandstone.—A greenish-gray to steel-colored, fine-grained sandstone formation, with beds averaging 15 inches thick; completely exposed in the rear of Craig's hotel, with dips of 42° to 58° (N. 5° W.) and a thickness of 85′.*

For. No. IV d. Medina Upper shales.—A mass of alternate olive and brownish shales, well exposed on the

*The Devil's Pulpit is part of this fine outcrop.

county road near Craig's store; and on the mountain side back of the store; where they are seen dipping 26° (N. 10° W.) The upper strike line outcrop runs along the mountain brow just north of the crest. Thickness, 180′

For. No. IV c. Medina White sandstone.—A mass of alternate greenish-gray, olive, and steel-colored sandstone beds; divided into two by a parting of sandy shale, twenty feet thick. The upper outcrop makes the crest of the Kittatinny or Blue mountain. Thickness, 70′.

For. No. IV b. Medina Lower shales.—Rather soft brownish shales, not well exposed at the Lehigh, with a few sandy beds. Immediately above the middle of the mass there is exposed a white conglomerate sandstone (25′ to 30′ thick), which may be a split from the lower portion of the Medina white sandrock of the Delaware gap. These shales occupy the crest and southern brow slope of the mountain, above the outcrop of the Oneida. Thickness, 330′.

For. No. IV a. Oneida conglomerate.—The upper *sandstone* division is a mass of massive white and light gray *conglomeratic sandstones.* Some of its lower beds are true conglomerates, with quartz pebbles varying from the size of a hazlenut down to fine sand. In its upper part fine-grained sandstones predominate; but the conglomerate character of the rock is apparent throughout its entire thickness. It is exposed in a long L. & S. R. R. cut, showing an anticlinal roll, with dips of 21° (N. 15° W.), 5° (S. by E.) and 31° (N. 20° W.) at the contact with the next underlying division. Its upper outcrop runs along the top of the southern slope of the mountain, beneath the mountain crest. It probably combines the Oneida shales and Oneida gray sandstone of the Delaware section; and is absent at the Schuylkill. Its thickness here at the Lehigh is 290′.

The lower division (*Oneida conglomerate*) immediately overlies the great Loraine shale formation (No. III) of the valley and dips conformably to the top beds of that formation. On the eastern side of the gap it makes a rib cliff running up the mountain, and a steep bench along the southern slope high up. Dip 24° to 31° (N. 20° W.) Section as follows:

Conglomerate of quartz and slate pebbles from the size of a walnut to fine sand, parted with thin beds of finer grained SS.,	62′
Sandstone: steel-colored, with an occasional bed of white SS. sand of nearly a uniform size, with an occasional pebble,	45′
Egg conglomerate of quartz and slate pebbles alternating with steel-colored SS.,	55′
Egg conglomerate of quartz, slate, chert, sandstone, and limestone (?) pebbles with one or two thin beds of grayish SS.,	8′
Total thickness to top of exposed Loraine slate,	170′

Notes on the anticlinals.

The whole region is thrown into gentle parallel waves, as represented by the vertical cross sections on the map sheets, ranging about N. 60° E.—S. 60° W.; rising eastward and flattening upon the great Pocono mountain upland between the Lehigh and Delaware rivers, and deepening westward to reach the coal measures of the Anthracite basins, between the Lehigh and the Schuylkill rivers.

These waves are grouped into a few grand anticlinals and synclinals; but each has its special character, name and place in the line of the section; which may be described shortly as follows, beginning at the north:

The great *Wyoming synclinal* or Northern Coal field, composed of several subordinate basins, is several miles wide, and still retains a maximum depth of 1600′ of coal measures, which dip into it from the north at a rate of 5° or 10°, and rise from its southern edge at various much steeper angles. This basin is fully described in other reports.

The great *Wapwallopen anticlinal* brings up from under the Wyoming mountain the *Pocono* and *Catskill* strata at 30°, diminishing to 0° and then going down again southward with a very gentle dip under the Nescopec mountain (*Pocono X*) and Conyngham valley south of it (red shale, *Mauch Chunk XI*). The character of this broad gentle arch may be imagined from the fact that the *Pocono* rocks, which make the crests of the inclosing Wyoming and Nescopec mountain, once rode over the arch at a height of only about 2000′ feet above the present surface. So, the Wapwallopen arch is almost the exact reverse of the Wyoming basin, except that it is unruffled—a plain smooth low single arch and nothing more.

The great Lehigh synclinal, 10 miles wide (from the Nescopec mountain to the Nesquehoning mountain), holds the Eastern Middle Anthracite field, thrown into numerous basins separated by subordinate anticlinals. These are in succession from north to south as follows:

1. The Tunnel Ridge anticlinal at Moosehead. A shallow basin lies south of it, and then comes,

2. A small roll north of Neleigh's cut on the L. V. R. R., south of which the south dip continues and deepens to the bottom of the *Yeager's Mountain basin.* This basin runs just south of Neleigh's cut and east up the valley of Upper Lehigh river. It is nearly symmetrical, with slightly steeper north dips. Yeager's mountain is a double basin, and ends in two synclinal spurs both eastward and westward, the northern spur the longer of the two. Here XII is perhaps 200′ thick, but it is hard to measure. No coal is known to remain on it.

3. The flat *White Haven anticlinal* carries the rocks over into the *Green Mountain basin*, its axis running along the north flank of its long, spur-like east end, and crossing the river 1000′ north of the L. V. R. R. bridge at the tannery.

4. Another anticlinal leads the rocks over into the *East Buck Mountain* (*Little Black Creek*) *basin*, the axis of which is seen crossing the river at Lehigh Tannery.

5. The *Lehigh Tannery anticlinal*, well exposed in an arch of Pocono rocks just south of the Lehigh Tannery, is the eastern prolongation of the Black Creek Ridge anticlinal of the coal field. South of it the rocks sink into the *Big Black Creek* shallow basin. The south dips are the steepest.

5. The *Sandy Run anticlinal roll** carries the rocks over into the *East Pismire Hill* (*Hazleton*) *basin*, the axis of which crosses the river 1000′ south of Sandy run. Its south dips are decidedly steeper (30°) than the north dips (10°) continued as far as Hickory run.

6. Several smaller rolls cross the river south of Hickory run, and the rocks then descend into the well-marked *Leslie's Run synclinal* (probably the eastward extension of the *Beaver Meadow coal basin.*) The series of folds just men-

* Crossing the river just north of the run.

tioned represent on the Lehigh river the *Drake's Creek coal basin* and its two enclosing anticlinals.

7. The *Bald Ridge anticlinal* crosses the river in a bold arch half a mile north of Stony creek mouth, with dips both ways (N. and S.) varying between 30° and 60°, and with several minor rolls upon its arch. To the west, up Quakake valley, it becomes the anticlinal which separates Spring mountain from Head mountain by a red shale cove. Although its north dip is flattened almost to a roll, its central axis crosses the river at the south end of the new L. V. R. R. tunnel. This fine anticlinal has red shale on its north slope, but brings the *Pocono* sandstones to the surface on its back and *Catskill* red rocks above the river level between Drake's and Stony creeks.

The *Penn Haven synclinal* lies south of it, its axis crossing the river about 500′ north of Stony creek, and then follows the course of the river to Penn Haven Junction, and so up the ravine on the west side of river just north of Quakake creek, and on (westward) up Quakake valley between Bald ridge and Nesquehoning mountain, until, sinking deeper, it takes in the *Head Mountain coal basin*. The basin is unsymmetrical; its south dips along the river above P. H. Junction often exceed 60°; its north dip never more and often less than 20°. It holds *Pocono* (X) rocks along its center line from Stone creek to Penn Haven, and thence westward a strip of XI.

8. The *Nesquehoning Mountain anticlinal* is a broad, flattish, undulating arch of *Pocono* (X) rocks, between the Quakake valley (north) and Nesquehoning valley (south). The highest line of the arch crosses the river south of Big Bear creek, and runs east through the heart of Kettle mountain. The rolls are chiefly on the northern slope of the arch, and may be looked upon as corresponding to the folds of the Mahanoy coal fields.*

The broad flat rolling arch elevates the *Catskill* (IX) red rocks all along the gorge of the Lehigh, which is full of fallen blocks of *Pocono* sandstone.

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*The Nesquehoning arch is a continuation of the great Broad Mountain arch, which separates the Middle from the Southern coal fields.

It has always been a popular notion that the Nesquehoning and Broad mountains were similar, and that it was as natural to find coal on the one as on the other; but the Pocono conglomerates (X) descend west beneath the red shale of Locust valley (XI) and the red shale of Locust valley descends west beneath the Pottsville conglomerates (XII) of Broad mountain; so that there is no good ground for expecting workable coal beds to exist on the Nesquehoning mountain, which is two formations older and about 4000 feet deeper than the Broad mountain. What little coal Nesquehoning mountain has belongs to the Pocono formation and is worthless.

Some of the Pocono conglomerates are very much like Pottsville conglomerate; and this is what misleads prospectors for coal. There is certainly coal in No. X; and in Southern Virginia it has been mined a little; but in Pennsylvania no colliery has ever been established on it; all attempts to mine Pocono coal have failed. One of the best known old openings is in the mountain at Duncannon on the Susquehanna river above Harrisburg. A still better show is made on Tipton run, in Blair county. A good many small beds, none of them of any value, were passed through in cutting the East Broad Top R. R. tunnel, in Huntingdon county. No. X coal has been found in a hundred other places in various counties of the State, but never of any money value.

A small coal bed has been opened on the north flank of Nesquehoning mountain, a mile south of Hudsonville Station (Mahanoy Branch L. V. R. R.), on top of the first ridge in view of the station. A shaft 38′ deep struck *coal slate dipping north* under the red shale of the valley. The slate was followed down the dip 80 feet, and abandoned "on account of water." The miners reported that they left off in 4½ feet of *coal* (not *coal slate*), and that the bed had suddenly increased its dip and was plunging steeply (north). Mr. Winslow could not verify this report, which must have been incorrect; for there was a large tip of *coal slate* at the mouth of the shaft, but *no trace of coal.* The slate bed is regular, for it has been proved at other places along its

outcrop; and it must have some little coal with it, for pieces of coal remain among the slate heaps; but the bed must be thin, for most of the tip is of mined rock and slate mixed. There is not the least hope that *workable* coal will ever be opened on the north or south flanks or any part of the broad top of the mountain.

The *Panther Creek coal basin*, ending at Mt. Pisgah (overlooking Mauch Chunk), crosses the river as the red shale basin of the Kettle, 1800′ north of the East Mauch Chunk bridge. Its south dips are nearly uniform, averaging 30°. Its north dips very soon turn up to 70°, and become vertical (90°), bringing to the surface from immense depths all the formations, XI, X, IX and VIII, to be measured for our river section.

9. The *Lehighton* (*Mahoning valley*) *grand anticlinal* turns them over to 30° south dips into the Wire Ridge (or Mahoning ridge) synclinal basin. This vast and simple rock fold has a sharp crest, which runs in a straight line (S. 65½° W.) from Stroudsburg, in Monroe county, to Pottsville, in Schuylkill county, 40 miles; crossing the Lehigh river in Carbon county at Lock 7. The total thickness of vertical formations brought to the present surface by this fold is nearly *three miles*; consequently the *Genesee black slate* which shows on the axis at Lehighton descends vertically and curves underneath Mount Pisgah at a depth of nearly *three miles.*

South of Wire Ridge basin there is no considerable anticlinal; but all the formations continue to rise to the surface until the Potsdam sandstone No. 1 comes up at Allentown and Bethlehem.

Glacial Moraine.

The *Terminal moraine*, a ridge of rocky trash of all sorts brought from the North by the great sheet glacier in the ice age and dropped at the foot of its front face, as fast as it was melted away, crosses the line of section in the valley of Sandy creek. This moraine crosses the river and the Pocono mountain upland eastward, descends the Pocono Knob southward to Lake Popocoming; crosses the Kitta-

tinny mountain, and sweeps south and east to the Delaware at Belvidere; crosses New Jersey to Amboy; runs the whole length of Long Island, and loses itself beneath the Atlantic beyond Cape Cod.

Westward it runs up the valley of Sandy creek, crosses Buck mountain, Hell Kitcken, Nescopec mountain, the Susquehanna river at Berwick, Shickshinny mountain, and gets at length upon the Allegheny mountain plateau, passing on through Lycoming and Potter counties into New York. Turning south-west it runs across Ohio, into Kentucky, and across Indiana, Illinois, Wisconsin and Minnesota into the British Northwest. It has been followed 2000 miles, and a description of it will be found in Report Z, 1884, with a map of the State showing how the whole region to the north of it is covered with Northern drift, glacial ponds, scratches, &c., &c.

The following occasional notes were made in the course of the survey :—

Near the head of Ashley Plain No. 2, *glacial striæ* were noticed in Pocono sandstone, with a north and south course, directly over the mountain.

On the top of Penobscot Knob there are several *rounded boulders* of white silicious sandstone from the ridge to the north, and also *striated* rock fragments.

Near Fairview L. V. R. R. station there is an exposure of hard sandstone well covered with south-west trending striæ.

Just north of Wapwallopen creek, near the L. V. R. R. line, there is a rounded hill apparently largely composed of *glacial drift.*

On the mountain, along the Bear Creek Branch L. V. R. R., there are frequent exposures of hard, gray, conglomeritic sandstone, well *polished* and *striated* in a southwesterly direction.

In the valley of Bear Creek, near the village of that name, there is an abundance of drift, with red shale and gray sandstone boulders.

Below *White Haven*, where Green Mountain run empties

into the Lehigh, there is a large accumulation of drift containing huge boulders four feet and more in diameter.

Further up the Nescopec Branch R. R. cuts through several deposits of drift; striated rocks were also observed.

On the top of Yeager's mountain masses of red sandstone were found which must have been brought up from below.

All the gravel and sand deposits which I have noted, it will be observed, are in the vicinity of water courses, and though glacial striæ and erratics are found on the mountain summits; apart from this, the country, I think, presents very little evidence of glacial action north of where Prof. Lewis locates the terminal moraine. Reference to the topographical description of this region will show that the surface is covered with angular fragments of the underlying rock.

Fossils.

Fossils are almost unknown in the rocks of the Lehigh river section from the coal measures down through XII, XI, X and IX; but shells are numerous in the *Chemung* and *Genesee* outcrops (VIII) near Weissport. Vegetable remains are occasionally seen in all the formations. The only indication of animal life seen by Mr. Winslow was in some obscure reptilian (?) footprints on a loose fragment of red shale at White Haven.

Report on the Metallic Paint Ores along the Lehigh River.

By Frank A. Hill.

History.

In 1856 Mr. Robert Prince, in exploring the lower beds of the Marcellus slates, between Millport and Bowmansville, Carbon county, in an effort to discover a portion of that formation with good cleavage planes and of sufficient hardness for a roofing slate, found an iron ore, the analysis of which convinced him of its utility as a metallic paint. At this time, owning a mill and water power on Big Creek, he immediately utilized it to grind the ore, and hauling the paint by wagon to Weissport, on the Lehigh River, found a ready market.

Ore for this mill was taken from the mine a mile and three-quarters east of Bowmansville, known as the Benjamin George mine, the present mine No. 4 of the Prince Manufacturing Company. The fact that this mine is still working and that the ore from it to-day has no superior, speaks well for Mr. Prince's keen perception and foresight. The ore at this time, though very costly to mine and prepare, was sold for $120 per ton on the cars at Weissport. The profits were therefore large, and naturally competitors appeared in the market.

From that time until the present mining plants have been made in various places and many changes in the ownership of mines and properties have taken place.

Mr. Henry Bowman, who, with Mr. Prince, was one of the pioneers of the Lehigh paint trade, after working individually for some time, organized the Carbon Metallic Paint Company. Mr. Lawrence, who was the next competitor operating as an individual, afterward organized the Lawrence Metallic Paint Company. Alfred R. Bass, who manufactured Standard Paint; Adolph Reiach, who manufactured Lehigh Metallic Paint; Marcus L. Smith, who owned the mill at Lehigh Gap, the trade name of which

paint I have failed to learn ; Solomon Snyder, who manufactured Snyder's Metallic Paint ; the Prince Manufacturing Company, who manufacture Prince's Metallic Paint, and Rutherford & Barclay, who manufacture Rutherford's Metallic Paint, have all at various times been in the trade. At present, however, December, 1886, there are but two mills manufacturing this paint, that of the Prince Manufacturing company at Bowmansville, and that of Rutherford & Barclay at Lehigh Gap. Of these the Prince Manufacturing Company, which is the offshoot of the original development by Mr. Robert Prince, was organized in 1876.

The firm of Rutherford & Barclay have been manufacturing for only a few months.

The history of the trade does not show any abnormally rapid development, but a steadily, healthy business growth.

Geography.

Along the southern border of Carbon county, about a mile and a half north of the crest of the Blue mountain, runs a clearly defined ridge known as Stony ridge or Devil's wall. This ridge is a very marked feature in the topography of the country, and is seen extending east and west of the Lehigh River as far as the eye can reach. It is along this ridge that the paint ore bed is found.

This ore bed has been developed in Lower Towamensing and East Penn townships of Carbon county, and West Penn township of Schuylkill county.

The eastern limit of development is about three miles west of the village of Little Gap. The western known limit of the blue ore is about a mile and a half west of Pennsville.

The best development of the ore is at Mine No. 4 of the Prince Manufacturing Company, one and a half miles east of Bowmansville.

The area of the least development is probably that west of Pennsville, the thickness and character of the ore seeming to depreciate from that point west.

Messrs. Thomas, Bower and Newhart, we understand, are

exploring for the paint-bed at Little Gap, with what success we have been unable to discover. Should they be successful, the area of paint development will be extended to the east three miles beyond its present known limits.

The villages of Pennsville, Bowmansville and Millport along the paint ore line, and Lehigh Gap farther south, are the center of population of the paint country, and are each the outlet for the product of the surrounding farming region. Of these, Millport and Pennsville, being away from the river and railroads, are not shipping points, and have little practical bearing on the milling and mining of the ore. Bowmansville is a town of 300 inhabitants on the Lehigh river, seven miles below Mauch Chunk, and 26 miles above Bethlehem. From its favorable location on the Lehigh Valley and Lehigh and Susquehanna Railroads it has become the point about which the mines and mills have centered. Lehigh Gap, which was once a shipping point for ore, has again become prominent, the large mill of Rutherford & Barclay, who have recently entered the trade, being located there. Lehigh Gap holds almost the same favorable railroad position as Bowmansville, the only difference being in the additional distance of the mines from the river bridge which crosses over to the Lehigh Valley station on the west side of the Lehigh.

Geology.

The summit and sides of Stony ridge are covered by broken boulders of Oriskany sandstone. This sandstone forms the backbone of Stony ridge. The crest is very sharp and well defined, and the sandstone, having a well developed thickness, gives the ridge the usual marked characteristics, a steep-dipping Oriskany hill.

The general section (see plate, page 1376,) taken in the Rutherford and Barclay tunnel on the north side of Stony ridge, in connection with the tunnel at Prince Mine No. 5 on the south side of the hill, gives a very thorough illustration of the rocks which form the crest and higher portion of Stony ridge.

No. 1 of section represents the bottom portion of the

Marcellus slate. The dips are so confused, and (in comparison with the Marcellus in its entirety the portion cut in the tunnel is so limited, that it is impossible to estimate the thickness of the Marcellus from them. One noticeable characteristic, however, is that in the Rutherford and Barclay tunnel, as well as at points to the east, this slate is extremely hard. Slates are quarried from the lower beds of this formation at Milford, two miles to the east, which are used quite extensively for roofing.

Number 2 of the section is a *cement bed*, and is found at every point where the paint bed has been observed. It is a very hard, fine-grained, hydraulic limestone. It thickens and thins; at some places being but one foot thick, while in others it reaches a thickness of 50 feet.

This cement was worked for a great many years, and it is said that all the masonry of the Lehigh canal was laid with it. The way it has stood is certainly a recommendation of its quality. The fact, however, that none of it is mined at the present day, although the opportunity for cheap mining and transportation is of the best, would seem to indicate its inability to compete with the cements of the present market.

This cement is probably the representative of the Upper Helderberg or Corniferous limestone.

No. 3 of the section is the *paint ore bed.*

Immediately between the cement and the actual paint ore there is a stratum of *clay* averaging about 6 inches in thickness. The thickness of the paint ore, which at some points is in one seam and at others in two, will probably average 2 feet. It was observed at one point in the Snyder shaft as low as 6 inches, and was reported (not seen) at a point in the Bass mine (east of Millport) to be 5 feet in thickness. [This thickness is given on the statement of miners who worked the ore. It is so much greater than at any observed point that its accuracy is questioned.] The greatest observed thickness was 3′ 7″ in Mine No. 6.

The paint ore is of a dull blue color, arenaceous, containing more or less pyrites, is magnetic, and in appearance

not in the least suggestive of the ore from which paint could be made.

Shaftings along the paint bed horizon (both east and west of its known workable limits) develop a reddish-yellow hematite ore. In driving the breasts up towards the outcrop the character of the paint bed changes into that of this same hematite ore. Occasionally streaks of hematite will be interleaved with the blue paint ore.*

No. 4 of the section, immediately underlying the paint ore bed and overlying the Oriskany sandstone, is composed of soft blue and yellow *clay* varying in thickness from 2 to 8 feet. In places the blue clay is entirely missing, while in other places the yellow clay is seen and the blue is missing. Wherever the blue and yellow clays are both seen the blue clay is nearest the paint ore. Where the paint ore is separated into two seams the intervening stratum is either a blue clay or a very soft blue slate.

Nos. 5, 6, 7 and 8, represent the upper beds of the Oriskany No. VII, and are highly ferruginious and calcareous; the sandstone and conglomerate layers rapidly disintegrate when exposed to the air, and for miles along Stony ridge sand quarries can be seen in continued succession, the sand in these quarries being the accumulated wearing away of the Oriskany sandstone ledge.

East of Millport and as far as the cross road passing Mine No. 4 of the Prince Manufacturing Company, a mile and a half east of Bowmansville, Stony ridge is single crested. It is broken through at various points by streams flowing south into Aquanchicola creek and the Lehigh river.

The dip of the paint bed at the Lawrence tunnel, one mile east of Millport, is 48° south. This is in reality an inverted north dip. At the shaft of the Prince Manufacturing Company, on the Snyder tract 1½ miles west of Millport, as well as in the shaft at their mine No. 2, a few hundred feet to the east, the dip is 68° north, while at the Rutherford & Barclay tunnel, which is at the extreme eastern end of this single crested portion of Stony ridge, the dip is but 50°

*Iron ore overlying the Oriskany sandstone is described in various reports of the State Survey.

north. At the cross road passing Mine No. 4 drift, which is nearly opposite the Lehigh Gap, a sharp flexure enters the hill and produces a double ridge, which continues from this point west beyond the Lehigh river. There is a small stream passing close to the opening at Mine No. 4 which flows south into the Lehigh. Notwithstanding a series of continued exposures, as well as the extensive developments of dips by mine workings, an accurate interpretation of the rock outcrops at this point is very difficult.

The interpretation of a transverse fault made by Dr. Chance in Report G[6] seems the most probable The existence of a synclinal in the most southern ridge seems to be represented by almost perpendicular dips in the tunnel of Mine No. 6, on the north side of Stony ridge, and of Mine No. 5 on the south side.

While there are no mining developments along the northern ridge, the exposed dips indicate one inverted north dip.

Within a mile west of the Lehigh river the south (or synclinal) ridge is lost in the gently dipping slope from the foot of the Blue mountains toward the Lizard creek, while the northern (or monoclinal) hill becomes a prominent topographical feature and extends west until south of the village of Pennsville it sinks into the low flat lands through which Lizard creek meanders.

One mile west of Pennsville the same ridge again rising continues to the west until, along the south side of the Orwigsburg anticlinal in Schuylkill county, the Oriskany No. VII rocks gradually disappear. The paint ore bed, resting immediately on the top of the Oriskany sandstone, follows Stony ridge within the limits indicated. While it has been shafted on the west bank of the Lehigh, no attempt has been made for its development between the river and Pennsville. There is no exposure of the blue ore between these two points, although its outcrop has been tested almost its entire length in the quarrying of sand. It does not necessarily follow, nor is it probable, that the ore does not exist here, the quarries rarely going more than fifteen feet below the surface, a distance much less than the average thickness of wash covering the paint bed where it has

been developed by actual mining. The paint bed is of course lost with the ridge under the flat land already noted south of the village of Pennsville.

North of Stony ridge the country is rolling and gradually rises in successive hills towards Wire ridge which attains an elevation of over 1,000 feet above tide

South of Stony ridge, the Aquanchicola and Lizard creeks have cut deep valleys in the Lower Helderberg and Clinton measures at the foot of the Blue mountain. Still farther south the Blue mountain shadowing these valleys rises to a height of 1,500 feet above tide, exposing along its crest the sandstone and conglomerate of No. IV.

Mining.

There are now nine separate mine openings producing the paint ore. Of these seven are owned by the Prince Manufacturing Company, one by Rutherford and Barclay, and one by Henry Bowman, the product of which is controlled by the Prince Manufacturing Company.

Through the courtesy of the mine owners all these mines were visited and in each case information necessary to show the character of the ore and method of workings was cheerfully given.

The most eastern mine now in operation is on the Lawrence tract one mile east of Millport and is operated by the Prince Manufacturing Company. Henry McFarlane is superintending the mine. It is worked by a rock tunnel driven a distance of 332 feet through shales and the hard flint sandstone and conglomerate beds of the Oriskany measures. The tunnel is driven about 5 feet wide by 6 feet high. Owing to a peculiar complication of ownership the mine has not been worked continuously; but the Prince Manufacturing Company having obtained control of interfering properties, active operations have been again commenced. The tunnel having been idle since 1885 several falls of clay closing the gangways made a thorough examination impossible.

To the north of the tunnel, and on top of the ridge, a shaft 73 feet deep was sunk some years ago, and from its bottom a gangway driven east 150 feet. But little ore was

found, and that only in "bomb shells" or lumps. On the west side a gangway was driven about 450 yards, the ore (Mr. McFarlane says,) averaging about 2 feet and of very good quality. Its minimum thickness was 1 foot while its maximum reached 3 feet. Breasts were worked from the shaft to the face. At the time the shaft was sunk the rock tunnel was owned by the Lawrence Manufacturing Company and the shaft level gangway which was 20 feet above the tunnel level was pulled down by the tunnel workings, the shaft was then abandoned and the tunnel property afterwards bought by Mr. Prince who is now the owner.

The tunnel level gangway on the east side was driven about 175 feet, but no workable ore was found.

The west tunnel gangway is driven 292 feet. A section at its face reported by Mr. Henry McFarlane (this section was hidden by a fall of clay when the mine was visited December, 1886), was as follows :—

Cement,	1′	
Slate,		6″
Paint ore,	2′	
Clay,	4′	
Sandstone,	—	—

The dip in the tunnel and in both east and west gangways is 48° south (inverted) and very regular. The ore mined at this opening is hauled by wagon to the kiln at Mine No. 4 where it is burned.

The next mine to the west, which is at present in operation is No. 2 of the Prince Manufacturing Company, who have recently purchased it from Solomon Snyder, Sr. This mine which is a little less than a mile west of Millport has been opened for about 5 years. The main opening from which the ore is hoisted is a peculiar combination of shaft and slope. The shaft was sunk 50 feet perpendicularly from the surface at which point, without any additional landing, a slope 50 feet long continues on a pitch of 50°. At the foot of this slope is the present working gangway. The east gangway is 125 yards in length. At its face the paint ore bed was very much pinched and is of course not a representative section of the mine. It is as follows:

Cement.
Clay, ... 7′
Paint ore, ... 6″
Clay, ... 7′
Sandstone.

The dip is 79°. Course of dip N. 10° W.

A section taken in the last breast 15 feet above the gangway and 50 feet west of the section noted above, shows:

Cement.
Blue clay, ... 3″
Blue slate, ... 6″
Paint ore, ... 2′
Clay, ... 7′
Sandstone.

The reported average thickness of the paint ore in the entire east gangway is 1′ 8″. 26 feet above the rail of the east gangway is the bottom of a gangway driven from the abandoned Kern mine to the east. There is also a gangway worked east from the upper lift of this shaft which is about on the same level. These upper gangways being so close to the present level leave a very short lift to be operated by the present east side workings. On the west side of the shaft the gangway is 64 feet long. At the time the mine was visited this gangway was stopped at the line between the Snyder property and the Prince Manufacturing Company. A section at the face shows:

Cement.
Blue clay, ... 3″
Blue slate, ... 7″
Paint ore, ... 5″
Slate, ... 3″
Paint ore, ... 10″
Slate.
Clay.
Sandstone.

The average thickness of the ore on the west side of the shaft is said to be 12″ which is in two divisions as indicated in section above. The observed dip was 69°; N. 15° W. The actual dip is probably a few degrees steeper. There is but one gangway on the west side of the shaft. It has a lift of ore 40′ in height the outcrop being covered by 60′ of debris.

The ore is loaded on a truck holding about ½ a ton the

body of which is hoisted to day by a stationary engine. There are seven men employed at this mine, which has a production of about 150 tons a month. The production of the mine is hauled to the oven at mine No. 4 and is there burned.

Mine No. 3.

Mine No. 3 of the Prince Manufacturing Company is 1⅛ miles west of Millport about opposite the Lehigh gap. The mine is opened by a shaft 67 feet deep. The mine working is superintended by Mr. Wesley Straup. The present supply of ore comes entirely from the west gangway. This is about 600′ long. A section taken at the face shows:

Cement,	40′
Clay,	3″
Paint ore,	6″
Slate,	7″
Paint ore,	1′ 10″
Slate,	9″
Clay,	6″
Sandstone.	

The dip is 68° north and continues very regular through the entire length of the gangway. The lift which is about 40′ to 45′ at the shaft is increased to about 60′ at the present face. There is about 20′ feet of debris covering the crop. The section taken at the face and given above is said to be a representative section of the west gangway.

The ore here is loaded on a truck containing about ⅔ of a ton, the body of which is hoisted from the shaft by means of a gin with one horse. The ore is hauled by wagon to the kiln at mine No. 4 where it is burned.

The gangway on the east side has been worked out and abandoned. This gangway (together with that from the abandoned shaft near the old school house at the road) has mined all the ore above the present shaft level as far east as the limit of the property.

West of the last-mentioned shaft is the new tunnel of Rutherford and Barclay the mouth of which is seen on the edge of the woods in the hollow leading from the mineral

spring. It is about 1500′ west of the shaft at mine No. 3, and 1200′ east of the cross road which passes the No. 4 mine kiln on its course toward Lehigh Gap. The tunnel is 649 feet in length, its course S. 10 E. and is driven through the bottom beds of the Marcellus slates, and the cement which at this point reaches its maximum observed thickness, (see general section page 1376). At the face of the west gangway the section is as follows:

Cement.		
Soft clay,		2″
Paint ore,		4″
Blue slate,		4″
Hard clay,		4
Paint ore,	1′	3″
Soft slate,		4″
Clay,	4′	

Dip 50° north.

A section of the bed in the second breast west of the tunnel shows:

Cement.		
Clay,		3″
Paint ore,		6″
Blue slate,		3″
Paint ore,	1′	1″
Blue clay,		2″
Clay and soft slate.		

Dip north 48°.

The lift here on the paint ore is about 40′. The distance from the gangway to the surface is 70 feet. There is no gangway as yet turned on the east side. The ore is burned at the mouth of the tunnel.

Mine No. 4.

The next mine to the west is Mine No. 4, which is opened by a drift and is operated by the Prince Manufacturing Company. This drift is on the east side of the cross road, already mentioned, leading from Millport road towards Lehigh Gap and is on the edge of the south slope of the hill overlooking the Lehigh river. This opening is one of peculiar interest in the study of the Lehigh paint ores. Owing to its low dips its method of mining differs from that of the neighbouring mines. It is of historical interest from the

fact that it is the point of earliest development of the ore and of geological interest as the mine which will ultimately develop the transverse fault which has, in so marked a manner, changed the character and appearance of Stony ridge. The drift is opened on the crop of the paint bed and is driven a distance af 275 yards. The dip at the face is about 24° north which is said to be the average dip from the tunnel mouth. A section taken at the face of the last breast shows :

Cement.		
Blue clay,		6″
Paint ore,	1′	
Soft slate,		3″
Paint ore,		6″
Soft slate,		4″
Clay and soft slate.		

About 300′ from the gangway the last breast meets a saddle the south dip of which is 11°. About 50 yards from the tunnel mouth a breast driven up the dip met this saddle at 50 feet from the gangway.

The mine car which holds about 1½ tons of ore is pulled out by a mule, it is then hauled to the kiln which also burns the ore from the MacFarlane and Straup mines.

Mine No. 5.

Following west along the south slope of Stony ridge overlooking the Lehigh River we come to Mine No. 5 operated by the Prince Manufacturing Company. This tunnel is about ¾ of a mile from Mine No. 4, and is about 1200 feet north-east of the village of Hazardville. It is opened by a tunnel 446 feet in length, which has cut through the sandstones, conglomerate and flints of the Upper Oriskany. The east gangway has been driven 90 yards. A section at its face shows :

Cement.	
Clay,	4″
Paint ore,	2′ 10″
Slate,	1′ 6″
Clay,	2′ 4″

The dip is 79° north. The average lift is about 60 feet to the wash which is 40 feet thick. About 35 feet above the gangway "Bomb shells" begin to mix with the ore.

The west gangway from the tunnel is 840 feet long. A section at the face shows :

Cement.	
Clay,	4″
Paint ore,	2′ 0″
Slate,	1′ 2″
Clay and soft slate,	3′ 8″

The dip at this point is 62° south (inverted).

On the west gangway the blue paint ore thickens and thins in many places and a yellow hematite of inferior quality takes its place.

None of the yellow ore is taken out.

Mine No. 6.

From the mouth of the mine the ore is hauled by wagon to the kiln at Bowmansville, where it is burned.

The Prince Manufacturing Company work another mine, No. 6, the mouth of which is seen on the north side of the wagon road leading along the river from Bowmansville to Hazardville. The drift mouth is at the foot of a slight rise in the road one-half mile below Bowmansville, at what are known as the Red Rocks. William Lower is superintendent of this mine. It is opened by a drift, the length of which is 2750 feet. A section taken in the last breast at the face shows :—

Cement.	
Clay,	4″
Paint ore,	3′ 7″
Slate and clay,	5′ 6″
Sandstone.	

For about 800 feet from the mouth of the drift the ore does not rise above the gangway high enough to give breast room but from this point a gradual rise begins and at the present face the breasts are worked up to a height of 75 feet. The distance from the gangway to the surface is 257 feet. The ore is taken out in a mine car holding about 1½ tons. The car is pushed by hand. The product of this mine is burned in the kilns at Bowmansville.

Mine No. 7.

The seventh and last mine operated by the Prince Manufacturing Company is located in East Penn township, one-

third of a mile west of Pennsville. Mr. Wesley Straup is the superintendent in charge of this mine. It is opened by a drift 1125 feet in length. A section at the face shows:

Cement.	
Blue clay,	7″
Paint ore,	7″
Blue clay,	3″
Paint ore,	1′ 2″
Blue clay,	1′ 9″
Yellow clay,	1′ 6″
Sandstone.	

The dip is 80° south. There is 15 feet of ore above the gangway which is again covered by 35′ of debris. This ore is taken from the mine in cars and pushed by hand. It is hauled by wagon from the mine to the kiln at Bowmansville where, with the other ores, it is burned.

Bowman mine.

The most western of the Lehigh paint mines is that operated by Mr. Henry Bowman. It is located a mile west of the last mentioned Prince mine about 1000′ south of the Lizard Creek and one and one-third miles from Pennsville.

It is opened by a drift, the gangway of which is 185 yards in length. A section in the last breast shows:

Cement.	
Blue clay,	6″
Paint ore,	1′ 1′
Clay and slate,	1′ 1″
Paint ore,	6″
Clay.	

The dip here is 18° west. The lift is about 45 feet. The crop is covered by 15 feet of wash. The product of this mine is sold to the Prince Manufacturing Company and burned in their ovens at Bowmansville.

Bass mine.

In addition to the working mines above described there are a number which are at present idle. The Bass mine is about a mile and three-quarters east of Millport. It is at present full of water and in consequence examination was impossible. We haye obtained the following information in regard to this mine from Mr. Henry Chestenbender,

which has been confirmed by several miners who worked in the Bass mine. The shaft is 62 feet deep and has a gangway driven 35 yards east and 50 yards west. There is a lift of about 30 feet of ore and 30 feet of wash covering it. Its average thickness is 3′. This ore was hauled by team to Lehigh Gap and from there, by way of the Lehigh and Susquehanna railroad, to Seigfried's bridge, where it was burned.

Reiach and other mines.

On the west side of Millport the paint ore was worked by a Mr. Reiach.

This and other openings which have been made at various points along Stony ridge are now abandoned.

Explorations.

Mr. William Thomas and others are at present exploring for the ore in the vicinity of Little Gap, but as yet their explorations have not sufficiently advanced to warrant their being classed as mining operations.

Cement quarries.

In addition to the mining of the paint ore along Stony ridge there has been a quantity of cement and casting sand mined and shipped. The cement, none of which is now sent to market, was originally quarried near the Rehrig mine. The cause of the suspension in shipment of this material is probably from close competition and from the greater profit found in the manufacture of paint. The sand which has been opened all along the crest of Stony ridge still finds its way to market in large quantities. It is principally used in casting, but it is also used in connection with fire clay in the manufacture of fire brick. It is used for this purpose at the McHose Works, at Allentown, as well as at fire brick works in Catasauqua and at Trenton, New Jersey. It is used, it is said, to great advantage in the lining of convertors in steel mills. At the Bethlehem steel works the Bowmansville sand has taken the place of the Gannister stone, heretofore imported from Scotland.

Later report by A. D. W. Smith.

The body of this report was written in December 1886. May 7, 1887, Mr. A. D. W. Smith visited the paint mines to discover what new developments, if any, had in the meantime been made. His report is as follows :

Hunsicker mine.

Hunsicker & Co. have opened a paint mine $\frac{3}{4}$ of a mile from the Henry Bowman Mine. The shaft which was sunk this spring is now full of water so that I am unable to examine the mines. I am indebted to Mr. Edward Christman who has charge of the Hunsicker & Co. mine for the following information. The shaft is 60′ deep. The paint bed will average about 2′ 10″ in thickness, 4″ of which is "stone ;" it is 38 feet in the shaft from the surface to the paint bed, the dip of which is 58°.

Bass mine.

Mr. Smith further reports that the Bass Mine shaft $1\frac{3}{4}$ miles east of Millport, is about 62 feet deep and that gangways have been driven 70 yards to the west and 60 yards east from the foot of the shaft. The average thickness of the paint ore is 26″ the dip being 85° south (inverted).

New shaft.

About a quarter of a mile east of the Bass Mine the Lehigh Paint Company are sinking a shaft. The paint was located by a rope drill some 72′ below the surface. They are now following this hole with a shaft.

New slope.

Mr. Smith also says that Mr. Rutherford is sinking a new slope to the paint bed about 800 feet west of the mill at Millport, but that the paint bed has not yet been cut.

Old shaft.

About 600 feet further west an old shaft was sunk years ago for iron ore. This iron ore bed is perpendicular.

New shaft.

Rutherford and Barclay also have a new shaft about 400 yards east of the Prince Mine No. 2, now down about 35 feet. They are exploring about 600′ east of Bass Mine but have not yet cut the paint ore.

Mining methods.

The system of mining adopted through the Lehigh Paint mines is one which precludes any waste of ore underground. In all the mines excepting the No. 4 Mine of the Prince Manufacturing Company and the Henry Bowman mine, the conditions are so much alike that a similar system is used in every opening. The gangways are driven about 6 feet high, the collars between notches being about 3½ feet with a 5′ spread at the bottom. The timbers are set from 3 to 4 feet apart and closely lagged. The gangway is always driven along the cement and the extra width necessary for the passage of wagons cut from the clay underlying the paint beds, an average thickness of 2 feet of clay being removed. In the No. 5 Mine of the Prince Manufacturing Company a single leg on the clay side and a collar is used, the cement being sufficiently strong to require no support. Wooden or very light second-hand rails are used along the gangway.

All the refuse from the gangway is hauled out and thrown on the waste bank outside. The breasts are opened at different widths along the gangway, the width depending upon the demand for ore. The greater the demand the less time is taken for opening deadwork and the width of breast is consequently shortened. In the steep pitching mines the shortest width of breast observed was 30′ while the longest was 100′. The ore is easily undercut in the clay and blasted. There is enough refuse clay and slate to fill the working breast to a sufficient height for the miner to work his ore. All the refuse from the breast is put in the gob and nothing but ore sent from the breast to the mouth of the mine. Few props are needed to support the roof, the greater danger being from slate falls in the working face. The hard

cement roof is so favorable to this system of mining that the loss of ore in the mine is inappreciable. As fast as the gangway advances the breasts are worked up and as they rise above the gangway level carefully timbered chutes are carried up as manways and also as rollways for the ore. In the low dipping workings of the Prince Manufacturing Company's Mine No. 4, and the Bowman mine a similar system is observed (modified to suit the dip), the only difference in mining being in the necessity for additional timbering and in the fact that the miner works on the bottom clay of the bed while the gob is piled on either side as the breast advances. In all cases a monkey gangway is carried along the face of the breast and air holes driven to the surface at intervals. The refuse clay is packed so tightly in the gob of the breast that there is no leakage of air and to a very complete and simple system of mining is added that of an equally simple and successful system of natural ventilation.

Drilling is done by the old hand drill and Atlas powder is very successfully used. At the lower mine however, black powder is used in the breasts, the superintendent considering Atlas powder too strong and liable to blow the ore into pieces too small for economical handling.

All the mines are worked by contract, a certain price per ton of ore being paid at the mouth of the mine.

The difficulties of mining are very few, in fact there seems to be no cause of trouble except that of surface water and this, while causing some discomfort to the miners, is hardly worthy of consideration in connection with the mining of the ore. The swelling of the clay when it becomes water-soaked occasionally breaks the gangway timbers, but this occurs more seldom than an observation of the condition of the bed would indicate.

Chemical composition of raw paint.

Samples were obtained from the Prince Manufacturing Company of the paint ore in its raw state, and of the paint itself when ready for market. It is very difficult to collect specimens of the ore in its raw state and of the manufac-

tured paint, which it would be fair to compare with each other, from the fact that it is impossible to get a fair average run of the mine and trace it through the processes of preparation. This is desirable in order to obtain samples of the run of the mill prepared from the same run of ore as that from which samples have already been taken of the ore in its raw state. The fact that the ore for the Prince mills is obtained from a variety of mine openings materially increases the probability of a greater irregularity in the run of the ore. It is but fair to state that in obtaining the samples from the Prince Manufacturing Company no special effort was made to meet this difficulty, which I think, may largely account for the difference between the analysis of ore and paint given below. No conclusion should be drawn in making a comparison of these two samples without a proper consideration of these facts. Both of the samples obtained from the Prince Manufacturing Company were sent to Mr. A. S. McCreath, chemist at Harrisburg, for analysis, who reports as follows :

The samples yield, when dried at 212 Fah., the following results respectively:

	Paint Ore.	*Paint.*
Metallic iron,	34.600	28.900
Metallic manganese,	.929	.983
Alumina,	5.492	10.608
Lime,	3.510	3.000
Magnesia,	1.081	2.028
Sulphur,	.674	.774
Phosphorus,	.018	.060
Silica,	16.210	37.790
Loss on roasting,	24.350	2.685

Mr. McCreath says: "In the raw ore the elements exist for the most part as carbonates, but no carbonic acid shows in the paint. It is very obvious that the paint does not consist of the roasted ore alone, but rather of this with a mixture perhaps of a red clay. This is suggested by the decreased instead of increased amount of iron ; and by the excessive increase in the amounts of alumina and silica from what the ore would yield roasted without any admixture. The sulphur is partially retained in the roasted ore perhaps by the presence of lime."

The paint ore in its raw state has a dull metallic blue color; is fine-grained, arenaceous and quite hard. There are occasional occurrences of iron pyrites. The ore when roasted, and ready for market, is in the form of a very fine powder, almost entirely devoid of grit and in color is a very rich, dark, reddish brown.

Preparation of the paint ore.

All the Lehigh paint ores are hauled from the mines to the mill by wagon. This is an element of cost which is difficult to overcome. A narrow gauge surface railroad seeming to be the only possible substitute. All the ore is burned before grinding, the object being the oxidation and calcination of the ore. This burning continues for 72 hours, making, it is said, an almost complete oxidation.

There are at present four ovens burning the paint ore and two additional ones in process of construction. The ore from Mines Nos. 1, 2, 3 and 4, of the Prince Manufacturing Company is burned at the oven just north of the No. 4 drift. This oven holds twenty-five tons of ore and has a burning capacity of 6 tons per day The paint ore from the No. 5, 6 and 7 mines of the Prince Manufacturing Company, and from the mine of Mr. Henry Bowman, west of Pennsville, is burned in the ovens of the Prince Manufacturing Company at their mills at Bowmansville. There are two ovens in use and one in process of construction at this point, which have a capacity of twenty-five tons of ore each with a possible production of six tons each per day.

The waste by burning is about 33⅓ per cent. The ore from the ovens at Bowmansville, together with that of the Rehrig or Mine No. 4 oven, after being burned is screened to remove loose clay and refuse, it is then wheeled into the mill and crushed to the size of a kernel of corn. In this condition it is ground by French buhr-stone, bolted and packed by machinery into barrels of 100, 300, 400 and 500 ℔s. in which it is shipped to market.

The Prince Mills, of which there are three, obtain their water power from the Lehigh canal, five 30″ in diameter, three 21″, and one 48″ turbine wheel producing power for

the crusher, grindstones, and the packer and bolter. One of the mills of the Prince Manufacturing Company is operating six pairs of stones, while the other two mills are operating three pairs of stones each. The completion of the new oven together with that of the new mill will materially increase the capacity of these works.

The ore from the Rutherford & Barclay tunnel is burned in the oven at the latter place. This oven holds 16 tons and has a capacity of seven tons per day. The average loss by burning is said to be 450 ℔s. per ton. The second oven, with a capacity of 22 tons, is being constructed and will soon be in operation. The ore from this oven is hauled by wagon from the Rutherford & Barclay mill near Lehigh Gap. The ore is screened in order to remove the clay and refuse, then crushed to the size of a kernel of corn, ground on French buhr-stone and packed by machinery.

The water power for the mill is obtained from Aquanchicola creek. The power being communicated by turbine wheels. There are six grindstones with a diameter of 42″ in operation at the mill. The production of this mill will be materially increased on the completion of the second oven now being constructed at the Rutherford & Barclay tunnel.

Shipment of the paint.

The mills of the Prince Manufacturing Company at Bowmansville are located between the Lehigh and Susquehanna and the Lehigh Valley Railroads. The wagon road which crosses the bridge over the Lehigh runs close to their mill. This being the case, the facilities for shipment are very great. Rutherford & Barclay's mill at Lehigh Gap is on the north side of the Lehigh and Susquehanna Railroad, and is enabled by means of the Lehigh Gap bridge to also ship over the Lehigh Valley road. These two roads and their valable connections give shippers along their line unusual advantages. The Lehigh canal, which is easily accessible both to the Rutherford & Barclay and the Prince Manufacturing Company's mills, is also important as a possible means of outlet.

Use in the arts.

The mention of the various purposes for which the paint is used is largely taken from the circular of the Prince Manufacturing Company. The paint is of great value to manufacturers of linoleums and oil cloths. Railroads use it for painting the iron and woodwork of bridges, for cars and metal roofing. It is also used in painting pipe joints especially those for steam and flange pipes. It is used where the prevention of corrosion is especially desired. In this connection its adoption and use by railroads in painting iron work and by the Government in preserving ordnance, shot, shell, etc., from rust is worthy of note. It is used for painting gas holders, petroleum tanks, varnish and water tanks, seashore buildings, canvass coverings, iron or wooden ships and especially for tin roofing. The United States Government have adopted it for coloring mortar in the construction of public buildings. The especial value of the paint rests on the claim that it requires no drier and mixes with linseed oil without changing the color. It requires one gallon of boiled or raw linseed oil to mix seven pounds of dry paint and is advertised to cover with one coat five hundred square feet of iron, tin or planed wood. Its extreme fineness prevents it from settling as the raw oxides are liable to do and for this reason there is almost no waste from sediment. The special virtue of the paint is its wonderful durability. It hardens under water and does not fade or scale. The fact of the presence of hydraulic cement probably gives it the power which is claimed for it of withstanding strong acids, gases and salt water, it therefore makes a good covering for all exposed surfaces.

Extent of market.

The market for the Lehigh paint ores is scattered all over the United States and Canada no special locality seeming to absorb this product. The main office for the Prince Manufacturing Company, No. 71 Maiden Lane, New York. That of Rutherford and Barclay, 305 Chestnut street, Philadelphia. There is little or no actual competition in

the sale of this paint as no similar material finds its way to the market. The only opposition it meets with is from the ochres which are mined in many parts of the Union. The retail circular price for this paint dry in 100 lbs. kegs is 2 cents per lb.

Probable quantity of paint ore.

A careful estimate (an exact summation being impossible) of the amount of paint shipped from the mills mining ore from Stony ridge shows a total shipment to January 1st, 1885, to be 50,000 tons, the maximum shipment 5000 tons was attained last year (1885). Of this quantity 4000 tons were shipped by the Prince Manufacturing Company. The present capacity of the Lehigh Paint mills is about 7500 tons per annum. This shipment will probably not be reached for several years. There is at present so much ore in sight above water level that any question of the exhaustion of the supply is far in the future.

I am indebted to Mr. A. C. Prince, President of the Prince Manufacturing Company, as well as to Mr. I. V. Ux, Superintendent of the same company, for their courteous assistance while collecting material for this report. I am also indebted to Mr. H. R. Rutherford for similar assistance and to the superintendents of the several mines whom each and all cheerfully extended me every possible assistance.

REPORT

ON THE

IRON ORE MINES AND LIMESTONE QUARRIES

OF THE

CUMBERLAND-LEBANON VALLEY,

1886

By E. V. d'INVILLIERS.

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The Iron Ore mines and Limestone Quarries of the Great Valley in 1886.

E. V. d'INVILLIERS.

Most of the iron ore banks described in this report are ranged along the north-west foot of the South mountains, in Franklin and Cumberland counties; along the valley of Mountain creek, between the two South mountain ranges, in southern Cumberland; at the east end of the mountains, in northern York county; and along the southern edge of Dauphin county, east of the Susquehanna river. The rest are scattered ore banks in the middle of the Great Valley; and a range of ore banks in Path valley, behind the North mountain.

The limestone quarries described in this report extend in a nearly straight line from the west side of the Susquehanna river, south of Harrisburg, along the southern border of Dauphin and Lebanon counties, to the Schuylkill river at Reading, in Berks county.

The Great Valley, of Silurian limestones No. II and slates No. III, extends from Alabama northward, through Tennessee, Virginia, Maryland, Pennsylvania, New Jersey, eastern New York and western Vermont, into Canada, everywhere holding similar brown-hematite iron ore mines.

In Pennsylvania it is called the Cumberland valley from the Maryland line to the Susquehanna river, a distance of about 70 miles. From the Susquehanna to the Schuylkill it is called the Lebanon valley, a distance by railroad from Harrisburg to Reading of 54 miles; and most of the limestone quarries described in this report have been opened along this line of railroad. From Harrisburg south-westward the Cumberland Valley railroad follows the middle line of the valley. The Harrisburg and Potomac railroad runs along the southern edge of the valley, past the iron mines to the

headwaters of the Yellow Breeches creek. The Dillsburg railroad branches at Mechanicsburg and runs to the Dillsburg mines. The Gettysburg and Harrisburg railroad branches at Carlisle and runs south, past Mount Holly Springs, and up Mountain Creek valley, to the mines at Pine Grove; it crosses the southern range of the mountains and reaches Gettysburg, in Adams county. The Mont Alto railroad branches at Chambersburg and serves the Mont Alto range of mines. The South Pennsylvania railroad branches at Marion station and runs north to the mines in Path valley.

East of the Susquehanna, the Cornwall railroad and the Cornwall and Lebanon railroad run side by side from Lebanon south to the Cornwall ore mines. In Berks county the Reading and Columbia railroad runs south-west from Sinking Springs into Lancaster county. There is also a Lebanon and Tremont railroad running north from Lebanon to the coal region.

The geographical position of the iron mines and limestone quarries and their relations to the lines of railroad just enumerated are shown on the maps accompanying this report. The names of the iron mines are given upon the map at their respective localities; but the limestone quarries are so numerous and close together that only their numbers are placed upon the map, and a list of corresponding names is given.

The floor of the Cumberland valley, and of its continuations southward into Virginia and eastward into New Jersey, is divided into two belts by a continuous middle line of junction between its slate lands on the North mountain side and its limestone lands on the South mountain side. Along this middle line the older limestone formation No. II sinks and passes underneath the slate formation No. III; not, however, with a gentle north-westward dip, but with a vertical or even overturned descent; so that along most of this middle line of the valley the limestone seems to lie on top of the slates, instead of passing underneath it. In Franklin county, however, a cross section from Chambersburg to Mercersburg shows the limestone, after having sunk be-

neath the first belt of slate, rising again to the surface; then going down under a second belt of slate and rising again; then under a third belt of slate, and a fourth at Mercersburg; and finally descending beneath the North mountain to rise again in the McConnellsburg cove. The first of these anticlinal belts of limestone runs into Cumberland county and points to the anticlinal cove in the North mountain opposite Carlisle.

Most of the dips in the valley are very steep, up to the vertical, and often overturned. Along the limestone belt next the South mountains the strata are closely folded and overturned. The whole country has been moved northward and westward, mashed together, complicated, wrinkled and distorted. In Franklin and southern Cumberland the southern edge of the limestone belt shows this overturned condition, the lowest limestone beds, with their iron ores, dipping not north-westward, *away from* the mountain, as would be expected, but south-eastward, *into* the mountain, as if going underneath the mountain sandstone (Potsdam No. I). In eastern Cumberland this overturned condition fades away, and the limestone strata take nearly their regular north-westward dip, the mountain sandstone evidently underlying them. How far this complicated geology is still further obscured by faults, along the foot of the South mountains, cannot be made out, because of the great amount of local drift, which covers the surface along Yellow Breeches creek.

The limestone formation No. II in former times undoubtedly overrode the first ridge of the South mountains (which is made by sandstone No. I), and basined in the valley of Mountain creek, where a long, narrow belt of it has been preserved, carrying its brown-hematite iron ores, similar in character to those of the Cumberland valley. The eastern end of the South mountain range exhibits anticlinal spurs descending into York county with remnants of the limestone formation between the spurs, and brown-hematite ore deposits in the limestone.

The Path valley iron ore deposits are also in connection

with the limestone formation which is brought to the surface by the great anticlinal arch of Path valley.

All the principal brown-hematite iron ore deposits, therefore, of the Cumberland valley, may be confidently said to range at the bottom of the Great Limestone formation No. II. The bottom strata differ from the strata of the middle of the formation in being more slaty and less massive. The ores have been produced by the mouldering down at the surface of these iron-bearing damourite slates into clay, the iron being peroxidized and concentrated in the clay as wash ore, ball ore and massive ore.*

In Lehigh county formation No. II has not only a range of ore deposits in the damourite slates at its bottom, but in similar slates at its top, along the middle line of the valley; as at the Ironton and Moselem mines. But from the Schuylkill river to the Maryland line no such great iron ore deposits occur along the middle line of the valley, at the top of formation No. II; and it remains doubtful whether the Path valley mines belong to the top or to the bottom of the formation, because the extent of the great fault which runs along the north side of Path valley has not been accurately measured.

The present surface of the limestone land is dotted over in a hundred places with small deposits of brown-hematite which have no connection whatever with the ranges at the top and bottom of the formation, but have resulted from thel ocal decomposition of some of the middle strata, or are accumulations of iron-bearing clays, preserved in pot holes; a number of them are described in this report, but most of those which appear on the map of the Cumberland valley, accompanying Mr. McCreath's report (M³, 1881) on the chemical constitution of the iron ores of the Cumberland valley are omitted from the map accompanying this report, on account of their insignificance or disappearance.

The iron ores which follow the Blue ridge in Virginia

*The process has been described in the various reports of the survey; especially in connection with the great brown hematite deposits of the valley in Lehigh county, and in connection with those of the Nittany and other valleys of Clinton, Centre and Blair counties, where the same ores rise with the same limestone formation No. II to the present surface.

have been divided into two groups or ranges; 1st, a lower, massive, and dense brown-hematite ore range, of a dark or even pitchy-black color, lying within the body of the Potsdam sandstone No. I; and, 2d, an upper range of richer, more cellular, brown or liver-colored ore, associated with the slates which overlie the Potsdam, and underlie the limestones of No. II.

The *lower ores* are usually more cold-short in quality than the *upper ores*; but the ores of both ranges in Virginia seem to be richer in metallic iron, with a less percentage of silica, than the general average of the Cumberland valley ores in Pennsylvania.

The Virginian *lower range* of ores is scarcely recognizable in our Cumberland valley region. The ore bed once mined in the mountains north of Thaddeus Stevens' furnace, on the Chambersburg-Gettysburg pike, and the ore beds opened in the face of the mountain opposite the pike, west of the furnace, must be referred to this lower group. All the mines along the foot of the South mountains, from the neighborhood of Mont Alto to the neighborhood of Boiling Springs, belong to the Virginian *upper range*, at the bottom of formation No. II.

The great variety of quality in the ores of this range, made apparent by the numerous analyses of Mr. McCreath, as well as by the practical experience of our furnacemen, cannot be explained, except on the supposition that there were infinite varieties of character in the original slate deposits from the decomposition or weathering down of which the ores have originated.

1. Older or lower range of limestone ore deposits.

To this range belong the various Mont Alto banks in Franklin county; the once extensively worked deposits near Cleversburg (east of Shippensburg), in Cumberland county; the Big Pond banks of the Philadelphia and Reading Coal & Iron Company, a little further along to the east; the large mines around Pine Grove furnace, and down both sides of Mountain creek to the Mount Holly Springs gap; and the extensive banks of the Philadelphia & Reading

Coal & Iron Co., east and south-east of Boiling Springs. They correspond to the Trexler range of ore banks in Lehigh county; and to many of the finest deposits in the Southern States and along the western line of the New England States, all similarly constituted.

The most important and most curious feature of this immensely extended range of brown-hematite ores is their local geographical distribution along the range; local groups are repeated at various distances along the range; the intervening barren stretches devoid of ore, far exceeding the productive areas. The ore formation as a whole seems to be nearly continuous from Alabama to Canada; but it is only richly ore-bearing at intervals; and where ore exists in large quantities there is every conceivable variation in its mineral character, and in its geological structure; the latter often presenting uncommon mining difficulties.

It is not to be supposed that this important ore range is yet thoroughly understood. Although it has been mined in Pennsylvania for more than half a century, and vast quantities of its output have been converted into pig metal, we are still far from knowing the true shape, the depth or the lateral extent of any one of the great deposits which have been wrought so long and assiduously. An incalculably large amount of good ore lies still concealed from view, and will undoubtedly be mined in the future; but the geologist who visits the region in 1887 can hardly appreciate the truth of this statement, if he merely regards the present aspect of the workings; especially if he compares their present condition with the much more active mining operations of only ten or fifteen years ago.

Long rows of idle or abandoned ore-banks are encountered; and it is only from the huge excavations which occur at nearly every mile of the ore-belt, from Maryland to the Susquehanna, that one can estimate the large quantities of ore that have been taken out. The region has had an eventful history. The records of the Mt. Alto, Caledonia, Pine Grove and Boiling Springs furnaces and forges testify to a copious manufacture of first-class iron; but not with a uniform prosperity. Great changes have taken place,

owing to the vicissitudes of trade and the difficulty of procuring ores suitable for the present market. Caledonia has long been out of blast. Boiling Springs furnace is now largely run with coke, on a mixture of Dillsburg and Virginia ores with the local hematites. At Pine Grove and Mt. Alto, both charcoal plants using purely local ores, the furnace stock is largely drawn from leased properties, able to furnish ore of better quality or greater cheapness; although both plants still own an abundance of ores close by. In fact, nearly all the famous ore-banks from which these furnaces once drew their supply have been abandoned, either on account of deterioration in the quality of the ore, or the increased expense of mining, or a combination of both.

The geological mode of occurrence of the ore-bed is largely responsible for this state of affairs; for had the ore-masses at the surface continued to run along the line of strike in as great abundance as when the huge open cuts were first worked, there would have been no necessity for mining at great depths, or for seeking elsewhere for good ore. But the universal testimony of those engaged in mining establish the fact, that at no great distance along the strike of any one ore-deposit, the ore-mass at the surface either comes to an end, or becomes too largely mixed with barren clays to warrant a further extension of the open cut. In all cases it became necessary to deepen the mine. While the stripping became too costly (the ore-mass pitching steeply *towards* and *under* the mountain) the mine had to be abandoned, for cheaper and more accessible workings. Moreover, the cavernous condition of a large portion of the Cumberland valley, making an extensive underground drainage system, and diminishing the surface water supply, has added largely to the expense of developing otherwise admirable ore territory. This scarcity of suitable washing facilities is especially true of a considerable stretch of the ore range, at the foot of the South mountains, east of Chambersburg.

2. Deposits of ore in the middle of the limestone belt.

The scattered ore deposits of the limestone belt of the Great Valley, average higher in metallic iron, and lower in phosphorus and manganese than those of the main range last described; but are as various in composition even at any one bank. They are in no sense persistent; all of them may be regarded as secondary deposits, washed into caverns and sink-holes in the limestone rocks, with a varying amount of foreign matter, the whole presenting an irregular mass of clay, sand and ore; so that the output will be good one day and bad the next. Hundreds of small pits have been opened by the farmers on each side of the Cumberland Valley railroad, between Scotland and Harrisburg. They are perhaps more numerous on the south side of the railroad; but whether north or south of it they are nearly all small excavations only furnishing 100 or 1,000 tons. But a few pits of considerable size have been made, from which several thousand tons of excellent ore have been taken. Such, for instance, have been the workings around Shippensburg and Scotland; and a few near Mt. Alto in Franklin Co.; the old Peach Orchard bank south of Centreville; some near Cleversburg; and a few near Mt. Holly and Boiling Springs in Cumberland Co. But by far the larger number have yielded insignificant amounts of ore, and have been long ago abandoned. Many of them in the fall of 1886 could scarcely be recognized; others had become the receptacles of stone refuse from the fields around.

Undoubtedly many new mines or diggings of this character could be made in this part of the valley; the geographical range is a wide one, and ore is as likely to occur at one place as at another. Several of the old mines also might be successfully worked again. But such deposits are so uncertain in their character, every where in this part of the Great Valley, as in fact they have been proved to be in the Schuylkill and Lehigh districts, that no one ventures to erect the machinery necessary to mine them properly. This uncertainty, added to the common lack of water for

washing the ore, and the distance of many of the banks from the railroads, has practically shut them out of the market and stopped this kind of mining throughout the valley. Indeed, there has been no open market for these ores for many years, not even during times of greatest activity in the iron business; and when any mining has been done, it has generally been under lease to some iron-master in the district, who has been temporarily shut off from his usual supply elsewhere.

The whole tendency of modern blast-furnace practice is towards utilizing the richest and purest ores; not only on account of the saving of fuel and flux affected, but to obtain better work from the furnace and a better grade of iron. Consequently these Cumberland Valley limestone ores, being neither particularly rich in iron (yielding say 40 to 42 per cent. in the furnaces), nor free from phosphorus and silica, are now neglected even by the iron-masters of the vicinity, who find it more profitable to depend upon the richer Cornwall and foreign ores, than to expose their furnace working to constant irregularity from the varying constituents of these brown-hematite ores. The day may come for a new and energetic development of these mines and quarries; but it is a certain fact that at the present time the people of the Cumberland Valley pay little or no regard to them and are content to cultivate and improve their magnificent farms, and leave the question of a good supply of well-prepared ore for local consumption to future generations.

3. Upper range of ore deposits.

The third range of ores at the contact of the limestone and slate has been more prolific; and in chemical character its ores resemble those at the foot of the South mountain, carrying much more manganese and phosphorus than those of the middle of the valley, averaging a mean between the purer grades of the lower ores at Mt. Alto, and the leaner, more cold-short ores of the Yellow Breeches creek. Typical representations of this upper series of ores occur in the vicinity of Mercersburg; and perhaps at the Richmond and

Carrick furnace banks along the South Pennsylvania branch of the Cumberland Valley railroad in Path valley. Not a ton of ore was being mined from this range in the Cumberland Valley during the fall of 1886; and on the whole the amount and character of the ore mined in the past in this district has been discouraging. Like the ores of the South Mountain range, these also are largely associated with barren clays and siliceous matter. They are difficult of access, and destitute of a proper supply of water for thorough cleansing; and no mining operation has met with much financial succes.

In connection with the three general classes of ore found in the Cumberland Valley district proper, it may be well to note the occurrence of two others:

4. *Bog ore deposits.*

The bog ores of Franklin county, accumulated on the surface of the slate belt, were once mined a little near Richmond furnace, and at the Leib, Stouffer and McFarland banks east of Mercersburg. About 10,000 tons of these ores were shipped from those openings up to 1880; but they are now abandoned. They seem to have originated from the decomposition of iron pyrites in the slates; and they are characterized by a *low percentage of phosphorus*, and an absence of manganese, which ought to make them a desirable mixture with the brown-hematites of the valley, carrying notable amounts of both these substances.

5. *Dillsburg magnetic ores.*

The Dillsburg magnetic iron ores occur in the Mesozoic or New Red sandstone of York county, associated with beds of impure magnesian limestone, which is the "gangue rock" of the ore. In many respects they resemble in appearance and chemical character the Cornwall deposit of Lebanon county (fully described in the Annual Report of 1885); and carry a low percentage of phosphorus. They have therefore been largely used in the manufacture of Bessemer pig-iron. Several of the mines are in active operation, and will be described later on. The ore itself

occasionally carries a considerable amount of iron pyrites, as well as lime and magnesia in the form of silicates, as do the ores at Cornwall, Reading and Boyertown.

Chemical analyses of ores.

The following table (republished from report M') exhibits a summary of the results obtained by Mr. A. S. McCreath, the former chemist of the Survey, from his analyses of 62 samples collected by himself in 1879–80, when the Cumberland Valley mines were more actively developed than they are at present. Mr. McCreath's analyses are repeated in this report for the convenience of the reader; and it should be kept in mind that the ores were all sampled by himself at the mines; and that his analyses were made of ore in the *dry state;* whereas the ores as shipped to the furnaces usually carry a percentage of hygroscopic water, sometimes amounting to 10 or 12 per cent., which materially *decreases* their percentage of *metallic iron* as compared with that of dry ore.

No. of samples.	Name of Group.	Iron.	Manganese.	Total iron and manganese.	Phosphorus.	Phosphorus in 100 parts iron.
6	I. South Pennsylvania R. R. *Brown Hematites,* . . .	44.341	1.009	45.350	.522	1.177
4	II. South Pennsylvania R. R. *Bog ores,*	38.087	trace.	38.087	.051	.133
13	III. Mount Alto Railroad, . .	46.054	1.114	47.168	.268	.581
6	IV. Shippensburg "*Limestone ores,*"	46.208	.599	46.807	.155	.335
8	V. Shippensburg, "*Mountain ores,*"	42.933	1.820	44.753	.667	1.553
12	VI. South Mountain Railroad,	40.083	2.057	42.140	.537	1.334
4	VII. Boiling Springs, ...	36.087	2.898	38.985	.947	2.624
3	VIII. Dogwood Run (Dillsburg), *Brown Hematites,* . . .	43.650	.703	44.353	.447	1.024
6	IX. Dillsburg *Magnetites,* . .	43.875	.102	43.977	.028	.063

The Mont Alto Iron Company's mines.

This company's extensive ore property is situated about 9 miles south-east of Chambersburg, in Quincy township,

Franklin county, with which place it has communication by means of the Mont Alto railroad. A large number of mines have been opened in the past on this property for the purpose of supplying the charcoal furnace at Mont Alto.

Many of these developments are at present temporarily abandoned; some of them are still in operation, but the property, as a whole, is not nearly so actively worked as it was some years ago, and presents more of a past and possible future, than a present.

The Mont Alto furnace has a working height of 50 feet; size of bosh 9½ feet; diameter of hearth 6 feet, and is furnished with four tuyers. Product, cold or hot blast charcoal; specialty, superior warm blast pig. In April 1887, the company were using ore from five mines: 1. Benjamin George; 2. Jacob Rock; 3. Promise; 4. Little Pond No. 2; 5. Guilford; and with this mixture produced a pig iron containing from 2 to 2½ per cent. phosphorus, and making neutral blooms. The limestone was being obtained from two quarries. 1st. The Mont Alto; 2d. The Harshman quarry near Quincy. The charcoal comes from the company's property in the South mountain. The greatest annoyance in the manufacture of suitable iron comes from the high silica in the ores, although the excessive amount of phosphorus in many of the banks, has also had its effect in limiting the choice of ores, many banks being idle from this cause.

The capacity of the furnace is about 30 tons, but has yielded as high as 35 tons in 24 hours.

The best 6 days run yielded 191½ tons, with 103 bushels of coal and 20 per cent. limestone, using about 2½ tons of ore to the ton of metal.

Col. G. B. Wiestling himself furnished, in a letter to Dr. Persifor Frazer, some interesting details concerning this property in 1875, and which will be found published in Report C p, 257 et seq.

The object of the present survey was to bring this data up to date, and of all the numerous openings on this property only the Pond, Promise, and Guilford were furnishing ore.

To Col. Wiestling, therefore, many of the statements which follow concerning individual mines are due; for in the abandoned condition of most of the old banks it was not possible to personally inspect many of the openings described.

The analyses of some few additional mines, not visited or worked, are likewise given for the purpose of comparison and as a striking example of how very apt the brown-hematite ore is to vary within very narrow compass. For reasons already stated in the introduction, it is hardly possible to group these ores either by geological horizon or analyses; the first is made obscure by surface drift; the second varies without rule.

Consequently all the mines in this vicinity will be described together, and the ore belt along the south and east side of the valley then followed to Dillsburg.

Mont Alto No. 1 bank.

This opening is situated but a short distance north northeast of the furnace. It has been abandoned for several years, and the Potsdam sandstone outcropping in the eastern side of the open cut, is now quarried there for the purposes of furnishing sand to the furnace. The rock dips to the northwest and a short time after exposure, disintegrates so rapidly as to furnish sand without the necessity of crushing it. The cut here is not a large one and was never very extensively worked. The ore evidently lies in the Potsdam sandstone formation. The cut has a diameter of about 60′ and is roughly oval in shape; no ore is exposed at present in any of the faces of the cut.

Mont Alto No. 3 bank.

This is a little further north-east along the flank of the mountain, lying close to the west side of the terrace of the main mountain. The cut is about 50 to 60 feet deep, though largely filled with water at present, and its sides greatly washed. The stripping on the mountain side of the cut is very heavy, and this fact probably led to the abandonment of the opening, although it is said to have been worked to

a depth of 120 feet. Limestone shows in the center of the cut dipping apparently south-east and creating a dome-shaped mass around which the ore was worked in the open cut. In the center of the opening a shaft some 50 feet deep was said to have passed almost entirely through lump-ore, although this fact cannot be taken as indicating the thickness of the ore-bed, inasmuch as this dip is quite steep towards the mountain, and consequently the shaft must have passed largely through the same section of the ore-bed. The ore is reported to have pinched east and west at this point, which, no doubt, is equally true in many of the banks situated like this. The old workings must have been quite extensive, judging from the size of the present excavation, which is 400 feet north and south, 300 feet east and west, and from 60 to 100 feet deep. The average grade of ore furnished at this place is said to yield about .66 per cent. of phosphorus in 100 parts of iron. Its analysis shows :

Analysis of the ore of No. 3 bank.

Metallic iron,	42.450
Metallic manganese,	2.543
Sulphur,	.044
Silicious matter,	18.870
Phosphorus,	.281
Phosphorus in 100 parts iron,	.661

Mont Alto, open Level, or No. 4 bank.

This is the next opening going northwards along the mountain terrace, and is almost within sight of the last opening. A very considerable amount of ore must have been taken from this opening, although at present work is entirely stopped. The open workings are only about 30 feet deep at present, although in places the cut has been extended to twice that depth. In the center of the cut a slope formerly extended to the underground workings and the existence of the ore has been tested to a total depth of 330 feet vertically. Limestone is also a conspicuous feature at this point, standing practically vertical, although the ore bed is said to have inclined toward the mountain as deep as it was followed, on a very stiff dip. In the eastern side of

the cut there is an exposure of very cherty limestone dipping 60° S. E. behind which there is evidence of calcareous slate. This mine was worked for fifteen years by Mr. Wiestling, and for a large part of that time furnished the sole stock for the furnace. Mr. Wiestling estimates that one hundred thousand tons of ore have been taken from this mine, nearly all of which was fairly neutral. The ore was not exceedingly rich in iron; but it was not mixed with free silicious matter, and consequently gave very good results in the furnace. In the lower workings both the foot and hanging walls were clay.

The analysis of this ore and that taken from an abandoned opening, No. 5, just north of it are shown together, as follows:

Analyses of ore from banks Nos. 4 and 5.

	No. 4.	No. 5.
Metallic iron,	48.450	46.350
Metallic manganese,	1.592	1.271
Sulphur,	.019	.026
Silicious matter,	13.070	16.750
Phosphorus,	.219	.236
Phosphorus in 100 parts iron,	.452	.509

Mont Alto No. 8 bank.

This is situated on this same outcrop of ore, probably one mile north of the furnace. Work was temporarily stopped here in 1883, owing to the expense of mining the ore on account of its depth and an awkward haulage to the furnace. The opening has a crescent-shaped form, 400 to 500 feet long and 150 feet wide. There seems to be everywhere from 20 to 30 feet of stripping. A somewhat prominent terrace shows on the mountain side within the cut where a shaft 100 feet deep passed through 30 feet of stripping, the balance being in ore. No limestone is seen in this cut, but the dip is still to the S. E. The general output of this mine showed an ore quite rich in iron and low in silica.

Analysis of ore from No. 8 bank.

Metallic iron,	54.200
Metallic manganese,	.569
Sulphur,	.067
Silicious matter,	7.870
Phosphorus,	.100
Phosphorus in 100 parts iron,	.184

Mont Alto, Smith and Avery bank.

This is situated about one mile west of Mont Alto furnace *and in limestone*, on the west side of the railroad and public road. Probably an acre of ground has been worked over here to a depth of from 15 to 30 feet with an increasing height of ore-face going northwards. This bank has been idle for some time. Quite an encouraging amount of ore can still be seen in various parts of the cut. It was claimed that this ore could be put upon the cars for $1 75 per ton, including a 25-cent royalty, and when last worked the cut was said to have presented a fine appearance for quantity along the east side. A decidedly good showing of fine wash-ore can now be seen at the north end of the cut, where it comes practically to the surface of the ground; but the general idleness in this section has very largely tended to spoil the appearance of the bank. All the ore mined here went to the Susquehanna furnaces, containing too much phosphorus to be used in the charcoal plant at Mont Alto.

Analysis of the Smith and Avery ore.

Metallic iron,	37.050
Metallic manganese,	.389
Sulphur,	.022
Silicious matter,	31.700
Phosphorus,	.415
Phosphorus in 100 parts iron,	1.120

Mont Alto Mill bank.

This (Mount Alto Iron Company) is another limestone opening on the west side of the railroad cut just opposite the Mont Alto stable. It also was idle and its ore largely concealed. The railroad passes through the center of the bank in a cut about 25 feet deep, on either side of which nests of ore have been taken out in the past, increasing its width irregularly. The cut is 500 feet long, and at present shows largely clay and partially decomposed lime-shales with which the wash-ore is associated. The ore does not seem to have much depth, extending only in places down

into the body of the clays. The company have abandoned all work here also on account of the too great percentage of phosphorus in the ore. The outcrop extends out on both sides of the cut into the adjoining fields; but nowhere seems to occur at greater depth than in the bank itself.

A sample of 125 pieces taken from the ore pile at the washer yielded:

Analysis of Mill bank ore.

Metallic iron,	48.250
Metallic manganese,	.180
Sulphur,	.075
Silicious matter,	15.200
Phosphorus,	.439
Phosphorus in 100 parts iron,	.909

Mont Alto No. 32 bank.

This is on the public road, one and a half miles N. E. from Mont Alto. The opening is on the Benjamin George farm, although the lease on the ore bank is owned by the Mont Alto Iron Company. The bank was being worked in May, 1887, and about a quarter of an acre of ground had been developed. Clay banks are frequent throughout all portions of that area, and the eastern portion was pretty well filled with water. The working faces near the road show a profuse amount of small lump and wash-ore, which crop extends for some distance north and south along the road. The cut is nowhere over 30 feet deep and by far the larger amount of development has been in the nature of stripping over the surface to a depth of ten to fifteen feet. The largest body of lump-ore reported here was unfortunately covered up with water at the time it was visited.

The ore material is all conveyed across the public road to the washer, and a shaft at that point also showed good results. A considerable amount of free silica is mixed with this surface ore, which necessitates hand picking after washing; but this is not found to be the case in the deeper workings where clay largely takes the place of the sand. About 15 to 20 tons a day of clean wash-ore are made here; but very little of it is lump at present. The washing ap-

paratus is very primitive, although the small quantity of ore washed daily permits of a very thorough cleansing. Its analysis shows:

Analysis of Mine No. 32 ore.

Metallic iron,	46.250
Metallic manganese,	.432
Sulphur,	.033
Silicious matter,	15.940
Phosphorus,	.437
Phosphorus in 100 parts iron,	.944

On the summit of a ridge running along the valley about one mile west from the mountain and probably half that distance from the last bank, there is in places, quite a profuse outcrop of ore. This ridge is no doubt a geological as well as a topographical extension of the Little mountain, which lies a mile further north and is composed of Potsdam sandstone rocks. South of the George bank the ridge is largely slate although limestone shows but a short distance down its northern flank.

Mont Alto, Ruth shaft.

A shaft has been sunk from the crest of this ridge of 220 feet, and was very dry. For 120 feet ore was found, mixed with a few pieces of limestone in loose boulders and clay. This shaft is in sight of "No. 32" mine, and about one-half mile N. W. of it. The limestone on the eastern flank of the hill seems to stand nearly vertical though leaning slightly S. E. The slates can be traced north for half-a-mile, and the ore outcrop accompanying them with a width of 150 feet, shows conspicuously for 400 or 500 yards along the hill. It is almost entirely wash-ore; but unfortunately no water is near at hand to cleanse it, so that no developments have been made at this point.

Mont Alto, Lucy mine.

This is another small opening or series of test pits about ½ mile east of the Ruth shaft. The analysis of both localities are given below:

Analyses of the Ruth and Lucy ores.

	Ruth.	Lucy.
Metallic iron,	51.600	48.050
Metallic manganese,	.057	1.772
Sulphur,	.012	.016
Silicious matter,	11.910	12.100
Phosphorus,	.100	.110
Phosphorus in 100 parts iron,	.193	.228

Mont Alto, Jacob Rock mine.

This adjoins the George farm on the north, towards the Little mountain. This mine has been opened entirely by underground gangways and was not in operation when visited in April. All the ore mined here goes to Mont Alto, and is apparently associated with the Potsdam slates.

The character of the ore is shown by the following analysis:

Analysis of the Jacob Rock ore.

Metallic iron,	47.350
Metallic manganese,	.749
Sulphur,	.066
Silicious matter,	16.020
Phosphorus,	.197
Phosphorus in 100 parts iron,	.416

McNeal bank.

The next openings are situated beyond the railroad at Pond Bank station. At this point quite a large amount of development has been done in the past, on both sides of the Little Mountain anticlinal, as well as in the synclinal basin between it and the main White Rock mountain on the east side of the valley. All the openings to the east of the public road are upon the land of the Mont Alto Iron Company, while the abandoned McNeal and Thaddeus Stevens Pond Bank workings lie on the west side of the public road and along the south-west flank of the Little mountain. Although these Little mountain ores show a considerable variation in quality and in the percentage of phosphorus which they carry, they are all more or less associated with the Potsdam sandstone slates occurring around the base of that mountain and similarly along the western slope of the main mountain itself.

Analysis of the McNeal ore.

Metallic iron,	**46.250**
Metallic manganese,	**.432**
Sulphur,	**.033**
Silicious matter,	**15.940**
Phosphorus,	**.437**
Phosphorus in 100 parts iron,	**.944**

Pond bank No. 1.

This is the first opening north from the railroad, formerly worked as an open cut, 80 feet deep, but now idle and filled with water to within 30 feet of the surface. There is absolutely nothing to be seen at this opening, although the ore taken from it in past times must have been large and is said to have been of a superior quality. The stripping varies from 10 to 30 feet.

Between this opening and the Little Pond bank to the north a shaft was put down by the Mont Alto Iron Company, with the following results:

Earth and white clay,	**10 feet.**
Sharp light-colored sand,	**5 "**
Clay, sand and pigment,	**25 "**
Black close-grained clay,	**1 "**
Lignite,	**4 "**
Gray sandy clay,	**1 "**
Lignite,	**18 "**
Sand,	**1 "**
Variegated clay,	**6 "**

The record of this shaft 71 feet deep was kindly furnished by Col. George Wiestling, and is certainly very interesting on account of the occurrence of the two beds of lignite. From the bottom of the shaft drifts were driven towards the two banks for the purpose of draining them.

Little Pond bank No. 2.

This lies about 200 yards north of the railroad, close to the base of Little mountain. It was formerly worked as a large open cut, although that method has now been abandoned for underground mining. Gangways have been driven southwards from the bottom of the shaft almost to the railroad, which is evidence of the flat structure of the ore-mass,

folding around the Little Mountain anticlinal; indeed the experience of the company sustains this view. To the north drifts have been extended under the old open cut, which was about 35 feet deep, and into which air shafts have been extended for purposes of ventilation. Two sets of levels are driven at the Little Pond bank and the ore stoped from them, the lifts being about 200 feet vertically apart.

The analyses of the ores of these two Pond banks are given together for comparison; for they would seem to be in precisely the same ore-bed, and within a short distance of one another, making the difference in result the more noticeable.

Analyses of Pond No. 1 and Pond No. 2 ores.

	No. 1.	*No. 2.*
Metallic iron,	50.550	48.600
Metallic manganese,	.309	2.154
Sulphur,	.054	.048
Silicious matter,	11.520	11.680
Phosphorus,	.157–158	.059
Phosphorus in 100 parts iron,	.312	.121

English mine.

This is located a little higher up the S. W. flank of the Little mountain, and shows a large open cut 200×150×30 feet, at present filled with water. More lump ore was obtained from this opening than from any other mine on the Mont Alto property; but at the same time it carried more phosphorus than any other opening and consequently has not been worked for many years. The ore dips here gently, but decidedly, to the S. E.; carries from 6 to 10 feet of overburden and is immediately overlaid by a black clay. A large amount of ore is said to exist beneath the present water sump; but of this nothing could be personally seen. An old analysis shows:

Analysis of the English mine ore.

Metallic iron,	38.350
Metallic manganese,	3.134
Sulphur,	.015
Silicious matter,	21.510
Phosphorus,	.849
Phosphorus in 100 parts iron,	2.213

Hope diggings.

These lie about 300 yards N. E. from the English mine, rather on the eastern flank of the Little mountain. No large amount of development has been made at this point, the few openings being merely to test the quality of the ore with a view to its possible improvement over that of the English mine.

Analysis of the Hope ore.

Metallic iron,	42.900
Metallic manganese,	.540
Sulphur,	.009
Silicious matter,	21.480
Phosphorus,	.464
Phosphorus in 100 parts iron,	1.081

Promise ore.

This lies well down in the valley, though rather towards the base of the main White Rock mountain. This mine is, at present, actively worked for the supply of the Mont Alto furnace. A large amount of ore was taken from the mine by open workings prior to the adoption of the present system of mining underground. The open cut is roughly circular, with a diameter of about 100 feet north and south, and possibly 125 feet east and west, and 40 feet deep. A well has been dug 75 feet deep in the center of this open cut for the purpose of furnishing water to the washers, and passed 70′ through wash ore and 5′ through limestone. Two gangways extend from the east side of the open cut towards the mountain, diverging slightly as they are extended, and only about 20 feet apart at the tunnel mouth. The most northern of these two gangways is 180 feet long, with side drifts driven north and south from different portions of the tunnel. The first pair of gangways extend about 20 feet into the ore ; the second about 30 to 35 feet, while the third is driven northward about 60 feet and southward 125 feet. The last pair are 40 feet long on the north side and 125 feet on the south, although a short distance on either side of the main gangway both of these drifts bend eastward towards the mountain. The southern

gangway had only been driven about 40 feet in May, 1887. Throughout the mine the ore dips to the S. E., about one foot in three. In the long tunnel two beds have been developed, separated by about 13 feet of barren clay; the first 27 feet thick and the latter 40 feet. In addition to this thickness of ore, probably 30 feet should be added for that taken from the open cut, so that the total thickness of ore-bearing clays here is not far short of 100 feet. The ore-mass is largely mixed with clays, but at the same time a very large proportion of the total bed thickness will yield a very handsome wash-ore. The ore as it passes through the washer shows quite a perceptible amount of sandstone lumps of about the same size as the larger ore pieces, but they can be easily hand-picked and thrown aside.

Analysis of the Promise ore.

Metallic iron,	54.600
Metallic manganese,	.336
Sulphur,	.037
Silicious matter,	5.775
Phosphorus,	.104
Phosphorus in 100 parts iron,	.190

Guilford, Wiestling, Limekiln, Calliman and White Rock banks.

The *Guilford Mine*, another active operation in May, 1887, occupies about the same geological position as the Promise, though nearly a mile south of that opening along the flank of the mountain. Between these two active mines there are three more banks which have been formerly to a greater or less extent. These in order southwards from the Promise, are, first, the Wiestling bank; second, the Limekiln bank; and, third, the Thomas Calliman bank, while the White Rock bank is situated higher up the flank of the mountain, about midway between the Promise and Guilford, and is to be referred to the Potsdam sandstone rocks. Of all these four idle openings it shows the highest percentage of phosphorus and was consequently but little developed for the Mont Alto furnace, whereas the Limekiln bank is comparatively free from that element. The analy-

ses of the ore from these four banks are given in tabular form below, from which a ready comparison of the variations in their constituents can be made:

Analyses of the 1, Weistling; 2, Limekiln; 3, Calliman; 4, White Rock ores.

	(1)	(2)	(3)	(4)
Metallic iron,	54.950	48.100	47.500	47.962
Metallic manganese,	.324	2.572	1.578	.477
Sulphur,	.036	.036	.019	.037
Silicious matter,	4.950	12.790	14.510	14.320
Phosphorus,	.087	.040	.070	.109
Phosphorus in 100 parts iron,	.158	.083	.147	.227

The *Guilford bank* shows an open cut 150 feet long north and south, 100 feet wide and from 20 to 30 feet deep. A long cartway extends from the cut to the washer. The ore is found on the summit of a flat ridge, a little west of the base of the mountain, so that for a considerable time to come the company will not be worried with the excessive amount of stripping, which has so greatly increased the cost of mining along the base of the mountain and led to the practical abandonment of mines showing a large quantity of ore, though carrying it under such circumstances as to hardly warrant its extraction. The overburden at this mine varies from 4 to 10 feet, rarely exceeding the latter figure. When visited the ore faces were largely cut up with lean clays and a considerable amount of surface drainage concealed the character of the bottom terraces of the opening. A larger amount of hollow bombshell ore has been obtained at this place than anywhere else, much of it very rich in iron, but so largely associated with clays as to require its being thoroughly broken up before carrying to the furnace. A second smaller cut lies a little S. W. of the main opening, showing a rich wash ore well to the surface of the ground. It, too, held about four feet of water so that the character of the lump-ore reported there could not be personally seen. The outcrop of this line of ore deposits, extending from the Promise mine to this point, is found to cross the railroad about 300 yards south of the last opening described, and passes thence into the Benjamin George farm.

Analysis of the Guilford ore.

Metallic iron,	52.500
Metallic manganese,	.663
Sulphur,	.019
Silicious matter,	9.110
Phosphorus,	.114
Phosphorus in 100 parts iron,	.217

Mines South of Mont Alto.

South of Mont Alto about 2½ miles, there are several old openings in the vicinity of Quincy on the Mont Alto railroad in Quincy township, Franklin Co. of which little can be stated beyond recording the analyses of their ores, for no work was in progress when they were visited, and none of them were ever extensively developed.

Robert McCleary bank.

This is in limestone, dipping S 70° E, 25° and is situated 1½ miles N. E. of Mt. Hope.

The opening is 150×50×15 feet deep and shows limestone in the center. There are 4 shafts in different parts of it, all fallen in, and very little ore shows anywhere. The character of the ore is largely of the pipe variety and occurs in a finely disseminated state through yellow clay. Almost all the ore has been gathered from the surface, and the following analysis shows its general character.

Analysis of the Robert McCleary ore.

Metallic iron,	52.950
Metallic manganese,	.403
Sulphur,	.026
Silicious matter,	8.500
Phosphorus,	.215
Phosphorus in 100 parts of iron,	.406

George Rock, Pass Orchard and Wythe Douglass mine.

These are three small openings apparently associated with the Potsdam slates, situated close together, along the west base of the South mountain, and about 1½ miles east of Quincy.

The first opening is about 50 feet in diameter, roug cular in shape and from 5 to 10 feet deep, and is t southern of the three. The two others lie further the order named above and were both idle when visi their sides entirely concealed.

The analyses of all three may be conveniently together, as serving to strongly illustrate the var especially in the manganese and phosphorus cons within narrow geographical limits.

Analyses of the George Rock, Pass Orchard and D ores.

	G. Rock.	Pass Orchard.	Dou
Metallic iron,	40.450	37.750	43.
Metallic manganese,	1.023	.093	.
Sulphur,	.029	.026	.
Silicious matter,	25.470	32.560	25.
Phosphorus,	.054	.469	.
Phosphorus in 100 parts iron,	.133	1.242	.

Mines in Cumberland county.

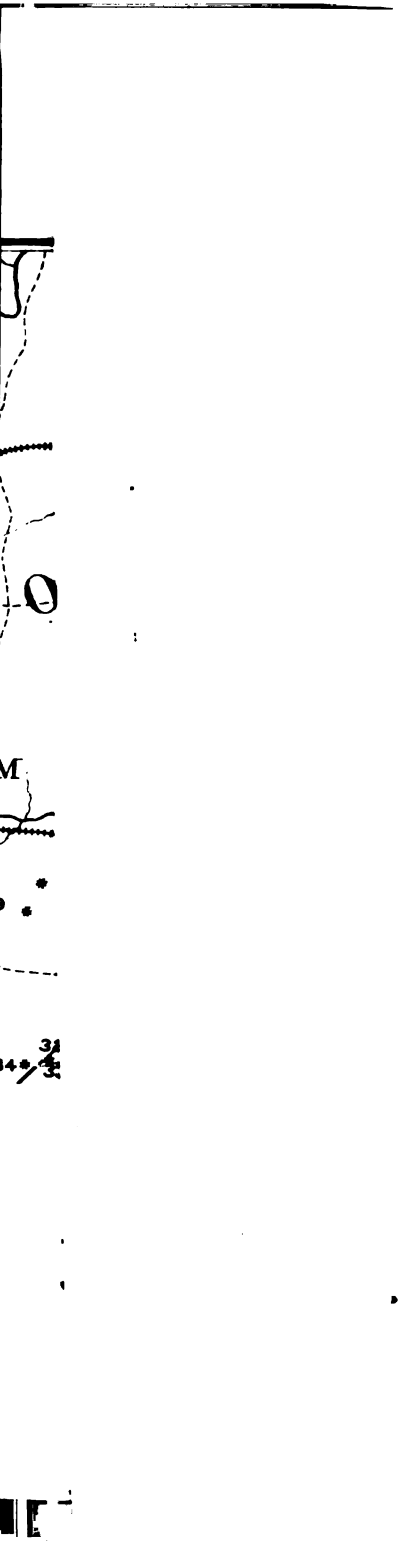
Along the base of the South Mountain range t continuation, with the usual interruption of outcro Quincy and Mt. Alto ores, and those which are mos allied to the horizon of the transition slates betw Potsdam sandstone and Silurian limestone formati

These will be described in order from the sout wards.

Old Southampton mine.

This lies about 3 miles S. S. W. of Shippensburg the south side of Furnace run. It is opened wel the transition slates, and the character of the amount of ore exposed there shows a distinct chang pearance from that of those bordering on the li formation. The bank has not been worked for years, so that the dilapidated condition of affairs there can be as readily imagined as described.

The pit is 150 feet long by 50 feet wide, and filled water to within 20 feet of the surface. About eigh



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very lean wash-ore shows near the surface, though largely covered with a dense white clay. Formerly this bank was worked for the old Franklin furnace, but no records could be obtained of the character of the material mined nor of its destination in later years. It is reported that a New York Company once leased this bank and after expending $20,000 (?) abandoned the mine without shipping any ore. There is very little evidence of any such improvement ever having been put upon this opening, and certainly very little to justify the expenditure of any money now; both on account of the distance from the railroad, and the character of the ore to be expected. When the old furnace, situated on the banks of Furnace run and within a stone's throw of the opening, was in active blast, this mine was no doubt economically worked; but the old stack is now entirely ruined and very few vestiges of its existence are to be found to-day; and it will need some very active demand from the iron world to warrant the re-opening of this and other abandoned openings in the vicinity.

The cold-short character of the ores is well shown by the following analysis:

Analysis of Southampton ores.

Metallic iron,	**45.550**
Metallic manganese,	**.728**
Sulphur,	**.013**
Silicious matter,	**16.460**
Phosphorus,	**.689**
Phosphorus in 100 parts iron,	**1.512**

Ruby or Plaster bank.

This lies close to the Southampton furnace site; but it too has been long since abandoned, and is owned or has been worked by the Cleversburg Furnace Company. It is practically in the same ore-range, lying but a short distance (400 yards) west from the base of the South mountain. An old analysis of its ore yielded results comparable with the Southampton mine, as follows:

Analysis of the Ruby or Plaster ore.

Metallic iron,	37.200
Metallic manganese,	1.642
Sulphur,	.029
Silicious matter,	24.250
Phosphorus,	.614
Phosphorus in 100 parts iron,	1.650

Gochenauer & Rohrer and Means banks.

These are small abandoned openings lying still further to the south-east and further up Furnace run, within the body of the Potsdam sandstone rocks, following the foot hills of the South mountain. They are within a mile of the Cumberland county line, but fully four miles from the railroad, so that their ore will hardly be required for sometime, taking into account their position and the character of the material as shown by the following analysis. The Means bank sample must have been an exceptionally favorable one.

Analysis of the Gochenauer & Rohrer and Means ores.

	G. & R.	*M.*
Metallic iron,	43.750	48.450
Metallic manganese,	1.356	2.031
Sulphur,	.028	.013
Silicious matter,	16.680	13.270
Phosphorus,	.531	.251
Phosphorus in 100 parts iron,	1.213	.518

Coffee (Ahl) and Peacock (Clever) banks.

These are two openings practically adjoining one another, situated about one quarter of a mile east of Cleversburg, and on the north side of the public road. Both present the same character of ore, a rather light brown hematite occurring in in small pieces mixed with slate, chert rock and some clay. This ore is all cold-short and in a compact hematite, with rather an attractive appearance, associated with the Upper Potsdam slates. The Coffee bank had only been abandoned about three weeks prior to the inspection on October the 29th, 1886; but even in that brief space of time, disintegration had well advanced, and had somewhat

effectually concealed the recent workings. The old workings. nearer the washer, had not been re-opened apparently, and showed only a confused mass of sand and clay, with a few small lumps of ore. The side hill had been cut and faced for about 40 feet, so that the position of the bank lays it open to constant destruction from land slides and mountain wash. The new portion of the cut shows a side hill face of mixed ore and tough yellow clay, the whole having a wavy structure and not overly rich. The bottom ground is the best, although the character of the deposit evidently did not meet the requirements of the market as evidenced by Mr. Ahl's abandonment of the cut. The stripping, at best, is fully 20 feet, and the ore material can hardly yield more than one-fourth or one-fifth clean wash-ore.

The Peacock bank was filled with water to within 20 feet of the surface and its sides entirely washed in. It lies to the east of the Coffee bank, and was opened for a width of about 60 feet along the hillside, the Coffee bank being 100 feet wide. The stripping is just as heavy here as in the larger opening, and the bank had not been worked for several years. The general character of the ore from both cuts may be judged from the analysis given below, and some of the Coffee ore seen on the dump at the Boiling Springs (Katharine Furnace) in November 1886, had been but recently condemned on account of its phosphorus, though once successfully used with other mixtures at this place. The ore breaks up into small lumps with a somewhat cubical fracture and was apparently readily washed.

Analysis of the Coffee and Peacock ores.

Metallic iron,	44.950
Metallic manganese,	.987
Sulphur,	.025
Silicious matter,	16.860
Phosphorus,	.535
Phosphorus in 100 parts iron,	1.190

Clever "Mammoth bank," No. 1, (P. & R. C. & I. Co.)

This is is situated a little further south-east from the Coffee and Peacock banks and closer to the main mountain. This bank was also in a very dilapidated condition, al-

though at one time it played an important role in the developments of this region, and its ore was largely mined and distributed. It is said that the possession of this property cost the Philadelphia & Reading Co., $80,000, and there is certainly very little to show for it now. The cut shows an opening, perhaps 200 feet long, 60 feet wide, and 30 feet deep to the level of the water now in the bottom, and is reached by a siding from the Harrisburg and Potomac railroad, and a short tunnel extended eastward from the stream to the small offset in the hill where this opening is located. As usual with these mountain ore deposits, especially those situated like this one, close against the mountain flank, this ore carries an exceedingly heavy stripping, which soon becomes a matter of great annoyance and expense to remove. Captain Howard, of Cleversburg, stated that a solid mass of lump ore exists beneath the present water surface, and furthermore, that when the mine was last worked the ore was found very costly to mine and wash and of uncertain quality, while always being extremely cold-short. An old section made here prior to the abandonment of the mine showed about eight feet of surface stripping; twelve feet of wash ore; six feet of mixed ore and clay, and nine feet of lump ore in the bottom. Probably 25,000 or 30,000 tons of ore have have been taken from this cut, most of which went to Harrisburg, Reading and Columbia; but at present this mine is a dead issue, and without a healthy demand for cold-short ores there is small prospect of its being worked again. Duplicate samples of this ore, taken by Mr. McCreath and Mr. Daniel V. Ahl, yielded upon analysis:

Analysis of the Clever "Mammoth Bank," No. 1.

Metallic iron,	36.800
Metallic manganese,	5.620
Sulphur,	.019
Silicious matter,	18.640
Phosphorus,	1.787
Phosphorus in 100 parts iron,	4.856

Big Pond banks.

These other of the Philadelphia and Reading Company's purchases in the Cumberland valley region, are really a series of openings, apparently situated geologically very much like the Clever "Mammoth bank," and probably within the slates occurring between the Potsdam sandstone formation and the limestone. This group of mines may be conveniently located at two miles south of Jacksonville, and about five miles east of Shippensburg. They are not a great distance from the line of the Harrisburg and Potomac Railroad, but despite that fact, none of them have been worked for a long time, although they are generally claimed to have furnished neutral ores, capable of making a first-class iron. It was probably this belief that led to the investment of some $200,000 in bonds and in cash in the above purchase from Mr. Ahl. The numerous small cuts, as well as the larger openings, are relatively shown on the map, and in their present condition they can hardly claim a more extended description. Variegated clay bands are exposed in the banks through which some fine ore is irregularly mixed; some of it quite cellular in character and more of it showing a fine grained but dense hematite of very attractive appearance. Some bombshell ore has also been obtained here in one or more of the openings.

A small, but fairly persistent, stream flows northwards through these openings before sinking in the limestone valley, taking its rise in the mountains to the south of the openings, and through a large portion of the year furnishing a good head of water. The openings however, are spread over several acres of ground, generally a little out from the foot of the mountain, which, in a measure, may account for the neutral character of the ore taken from them.

Many of these openings can scarcely be recognized now from the mass of dirt and wash-material which has partially filled them up. But reliable sections taken in the most southern and perhaps the largest of these cuts during its active development showed 22 feet of white clay, with a

few ore lumps, as a top covering, beneath which there had been exposed some 20 feet of rich lump and wash-ore. Elsewhere the stripping only amounts to about 6 feet before good material is reached, while the limestone ore-bank belonging to this property, and situated further west than the other large openings, once contained a shaft put down from the bottom of a 30-foot cut in good wash-ore, which passed through 50 feet of mixed ore and clay before striking limestone having a gentle S. 20° E. dip toward the mountain. Limestone of a similar character was found elsewhere in this cut and in other small openings near by and while being quite ferruginous, was largely used as a furnace flux. For a long time the ore mined here prior to the purchase by the Reading Company was used without a mixture with other ores in the Big Pond furnace, half a mile further east, where it made a neutral iron classed as No. I by its consumers. The quantity of ore removed from the various openings here has been computed at anywhere from 100,000 to 150,000 tons; but although some six thousand acres of land are supposed to have accompanied the sale of the property to the Reading Company, it is very doubtful whether the investment ever proved a source of profit or interest to that corporation. The following fairly represents the character of the ore:

Analysis of the Big Pond ores.

Metallic iron,	44.000
Metallic manganese,	1.275
Sulphur,	.030
Silicious matter,	20.520
Phosphorus,	.318
Phosphorus in 100 parts iron,	.722

George H. Clever bank.

This lies about 300 yards east from the Muslin bank and nearly midway between Cleversburg and the Big Pond openings. It shows a roughly oval pit, with a diameter of about 100 feet and about 40 feet deep. Though but recently pumped out, the bank on November the 1st, 1886, exhibited but little attractive ore, inasmuch as there had

been no opportunity to expose any new ore-faces. The overburden is about 10 feet thick, and the wash-ore is associated with white, yellow and red clays, evidently occurring in the lower portion of the limestone formation. No special part of the bank showed better or worse than another; but a 20-foot band of barren clay somewhat spoiled the appearance of the western side. The ore is reported to be of excellent character though leaning to cold-short, and lies conveniently for development by means of an inclined plane, providing the pumps are kept fairly active. The small top covering makes the removal of the ore comparatively simple and inexpensive compared with many operations in the valley. No special facts could be obtained concerning this deposit except from some laborers on the ground who volunteered the information that the bank was to be started up during November 22, 1886. The analysis of its ore gave:

Analysis of the George H. Clever ore.

Metallic iron,	50.620
Metallic manganese,	2.111
Sulphur,	.027
Silicious matter,	7.750
Phosphorus,	.553
Phosphorus in 100 parts iron,	1.090

Grove or Peach Orchard bank.

This lies about two and a half miles E. S. E. of Jacksonville and close to the South mountain, and one mile south of the Yellow Breeches creek, on a small branch of that stream. The Harrisburg and Potomac railroad at Jacksonville is the nearest shipping point to this operation, which, however, has been long abandoned and has not required any facilities of the kind for the movement of its ore. Augusta and Cumberland furnaces ran many years mainly upon ores from this bank, which were then extensively worked, and it is estimated that at least 50,000 tons of ore have been so mined; a total rather under than over estimating the quantity won here, judging from the size of the excavation. The locality is very much deserted at present

and no information whatever could be obtained concerning the ownership or the prospects of an early renewal of work. The analysis of an old sample of this ore yields :

Analysis of the Grove or Peach Orchard ores.

Metallic iron,	44.950
Metallic manganese,	1.693
Sulphur,	.008
Silicious matter,	15.950
Phosphorus,	.746
Phosphorus in 100 parts iron,	1.659

Old Peffer bank.

This lies about 2 miles west of Papertown, half a mile south of Barnitz station on the Harrisburg & Potomac railroad, and 350 yards south from the track toward the mountain. It must lie close to the junction of the limestone and sandstone formations. It has no outlet to the railroad and no machinery, and while the ore is highly spoken of, the mine has evidently been abandoned for many years, although within close proximity to the Harrisburg furnaces. The pit itself is not any more favorable in appearance than five or six acres of ground north and west of it. The bank presents an open cut from which probably 3,000 cubic yards of material have been mined and probably screened for shipment, inasmuch as no water or washer could be seen in the vicinity. The analysis of this ore is very favorable, but was made from a sample consisting of a number of loose pieces picked up around the mine. The results are as follows :

Analysis of the Peffer ores.

Metallic iron,	54.200
Metallic manganese,	.086
Sulphur,	.045
Silicious matter,	6.560
Phosphorus,	.206
Phosphorus in 100 parts iron,	.308

Mullen or King bank.

This lies on property of the Mount Holly Paper Company, in front of the Mount Holly gap in the South mountain, about one mile west of the village and a half a mile from the forks of the road at the cooper shop. It lies about 200 yards south of the road and toward the flank of the mountain, consisting of two pits somewhat rudely connected, the most southern one being filled with water to within 25 feet of the surface and in which, therefore, everything is effectually concealed, except a limited amount of fine wash top ore, occurring along its southern side. As might be expected from its position, this bank is exposed to a vast amount of surface-wash from the mountain, and the character of the ore seen in it was so largely mixed with chert and small boulders of sandstone as to render it very unattractive in appearance. A strip of white clay 20 feet wide extends N. E. and S. W. across the mine, back of which to the east, some yellow ore-bearing clay occurs with varying richness. Between this pit and the washer the second opening occurs, in which no work has evidently been done for many years. Trees of considerable size were growing in the bottom and comparatively little ore shows beneath the sod which has sprung up since its abandonment. The dirt and clay banks around the mine are large, and while the character of the ore is reported as good and its quantity not insignificant, it certainly must have occurred with such a large percentage of foreign material which in the absence of water for washing rendered it difficult to prepare properly and to mine with economy. A record of a bore hole put down in search of water, which was kindly furnished by Mr. D. King, the last lessee, showed surface clay 8 feet; ore-bearing clays 128 feet, and then limestone.

The occurrence of limestone even at this depth so far up the mountain flank is both interesting and suggestive, for it would serve to carry the outcrop of that rock much further to the south than is usually inferred from the sur-

face exposures.* The ore from this bank was used at Steelton, Newport and elsewhere, and its shipments, according to Mr. King, were of uniformly good quality. Very little solid lump ore was met with in the opening or trial pits, although a considerable proportion of the output was lump ore; and the deposit was largely confined to the ravines, not extending far in either direction along the mountain flank. The analysis of this ore fully warrants the good reputation given it:

Analysis of the Mullen or King ores.

Metallic iron,	44.900
Metallic manganese,	1.837
Sulphur,	.022
Silicious matter,	16.180
Phosphorus,	.392
Phosphorus in 100 parts iron,	.873

Mountain Creek mines.

Mountain creek is a branch of the Yellow Breeches, which it joins about 1½ miles north of Mt. Holly and a little west of the Gettysburg and Harrisburg railroad.

Going south from Mt. Holly Springs along the line of the Gettysburg and Harrisburg railroad, there is a fine exposure of the Potsdam sandstone measures in the gap of Mountain creek. The dip throughout is toward the S. E. and the section is made up of a series of thin-bedded quartzite strata about a thousand feet in thickness. No north dips can be observed in this gap although it is quite possible that some of the exposures toward the west end are overturned and consequently duplicate the thickness of the rocks at this place.

The creek itself flows in a north-easterly direction between the second and third mountains of the range, from its source in Adams county to the Papertown mills. This nar-

[*This record is more important for furnishing one of the few rare facts on which to base the probable theory that all the S. E. dips at the foot of the South mountain are overturned dips. There seems to be but one alternative to this theory, viz: the theory of a continuous fault or faults.—J. P. L.]

ow valley is a synclinal basin still holding remnants of the limestone formation in different parts of its area, notably at Pine Grove furnace and on the west flank of the mountain south-west of Hunter's Run station. Potsdam sandstone rocks, however, make the sides of the trough, and make the débris from these rocks largely occupy the valley and conceal the true limestone floor. There can be but little doubt that the limestone formerly occupied a much larger area in this district and probably overrode both ridges whose summits are now entirely bare of all calcareous deposits.

Wild Cat pits.

These mines of the South Mountain Mining and Railroad Co. are two and a half miles S. W. of Pine Grove furnace, and further up Mountain creek. No operation was ever conducted here, although the ground was thoroughly tested by a large number of shafts 30 to 40 feet deep, nearly all of which are reported to have passed through ore material and are supposed to have developed one of the largest bodies of ore in the mountain. While the percentage of iron in the ore found here was sufficiently high (50 per cent.), the phosphorus was excessive (1.3 per cent.) for purposes for which the company would have required it.

Analysis of the Wild Cat ore.

Metallic iron,	48.200
Metallic manganese,	.367
Sulphur,	.025
Silicious matter,	12.800
Phosphorus,	1.365
Phosphorus in 100 parts iron,	2.831

Red bank (Thomas Iron Co).

This is an old abandoned opening, on the Bendersville road, one-half mile S. W. of Pine Grove furnace, which shows an oval pit 100×60×20 feet deep, absolutely devoid of all visible ore and showing only a mixture of clay and sand, with a little ore on the north side. It has never been claimed that this locality was of any special importance, nor has there ever been much ore mined from it.

Pine Grove bank No. 1 (S M. M. & R. R. Co.,).

This is situated about half a mile E. S. E. from the furnace and was not being worked at the time of inspection. At the west end, the cut shows about 60 feet deep. The stripping here was only originally about ten feet of clay and sand, under which 25 feet of wash-ore and clay occurred and then 25 feet additional of a solid but soft lump ore to the bottom of the cut. A drift was driven S. W. for about 200 feet at this point, and at 150 feet a left hand cross-cut was driven fifty feet to the S. E., all of which development was through ore. No inspection could be made of these tunnels, and for this statement and many of the facts concerning this deposit of ore I am indebted to the Superintendent, Mr. Daniel King.

No ore, as yet, has been robbed from this south-western portion of the bank, and it is claimed that it is largely No. 1 neutral ore from the surface down to the lump-ore. Any drift driven S. W. from this bank will come out in the "Old bank," and it is fair to assume that the ore body is continuous between the two openings. All along the south side of bank No. 1 a splendid face of lump-ore was partially exposed during the fall of 1886, since which time the mine has been allowed to fill up. At the S. E. end of the excavation, another drift 200 feet or more long, with numerous stopings, has uncovered an excellent mass of brown cellular ore which is largely the characteristic feature of this deposit now as formerly. A large "horse" of white clay still occupies a place in the east workings; but ore occurred disseminated all through it and around it and excavation on both sides of this generally barren dome of clay show excellent ore. A rotten dolomitic limestone crops to the south of this clay mass. Its dip is obscure. The bank probably shows an extreme length of 1000 feet; it is 200 feet wide and averages 60 feet in depth.

From 1879 to 1885 this bank has furnished about 75,000 tons of wash ore. And with other neighboring operations, probably twice this amount prior to 1879. The ap-

pearance of the ore deposit is very favorable, despite its temporary abandonment, especially along the southern edge towards the hill. The northern side of the cut, in the vicinity of the washer and pumps, was greatly washed and concealed; but in general it does not seem quite as rich on this side, and shows a conspicuous amount of black clay there. Mr. King states that the lump-ore in the bottom of this bank is found, on repeated trials, to give on an average 2.25 per cent. of manganese and about .225 per cent. phosphorus, so that a great deal of really excellent lump, carrying from 40 to 42 per cent. metallic iron, is practically untouched on account of the deterioration of quality due to the mixture of the two first named ingredients. The analysis of the ore from this mine as determined by Mr. McCreath from samples taken by himself in 1881 shows:

Analysis of the Pine Grove ore.

Metallic iron,	42.150
Metallic manganese,	2.709
Sulphur,	.028
Silicious matter,	20.900
Phosphorus,	.275
Phosphorus in 100 parts iron,	.652

Pine Grove Old bank (*S. M. M. & R. R. Co.*).

This is situated immediately on the south side of the hill against which the No. 1 bank is developed, and is but a short distance from the larger opening. No ore has been taken from here for many years and only the fact of a large excavation being visible remains to confirm the reports of the large tonnage formerly won here. All dips of both ore and limestone seen in these banks were to the south-east, and no developments by shaft or otherwise have determined any change to the north in that dip. It seems to be quite well established, that the proper method of mining these ores is by drifts and tunneling underground; for though there is apparently an increase of 50 per cent. in cost for timber, etc., over that of working the same character ore in an open cut, yet, by reason of the ability to work

around clay deposits in drifts only requiring to cut through them once in the main tunnels, only the best ore material need go to the washers and the dirt to be moved is comparatively slight. Additional security is also obtained by the underground method of working for removing all that portion of the ore-mass (and it is usually the best) occurring against the mountain slope; for it takes but a small amount of development by open cut to increase the overburden to such an extent as to make it practically impossible to obtain the ores beneath without having to remove a vast quantity of barren material and make the ores cost more than they will bring.

Laurel bank No. 1.

This is (at present worked under lease to the Pine Grove Furnace) close by the station of that name on the South Mountain railroad, two and a half miles N. E. and down the stream from Pine Grove. The ore found here is a mixture of small lump cellular ore, yielding readily to the pick, and a hard lump bottom ore, requiring blasting. Both classes of ore here are richer in metallic iron than the Pine Grove ore; but neither, it is claimed, so pure or neutral as that which was formerly mined at the large bank near the furnace. At present, however, the company depend largely upon this Laurel No. 1 ore, together with a mixture of the Lehman ore, near Hunter's Run station, for the manufacture of their neutral pig. The excavation lies on the north slope of a terrace of the main mountain, and shipments have run as high as 150 tons a day, although rarely averaging that. It is claimed that the ore-material in this bank will run nearly one-half clean wash-ore; but this can only be true of the massive lump variety, which is generally largely free from the tough clay associated with the wash-ores. The dip throughout this mine is to the S. E., though with a somewhat wavy structure in places, and temporary N. W. dips. The northern side of the excavation presents a very lean face, although some good ore-material was being won from this side of the bank while developing the cut to a lower level.

The ore-deposit has been quite extensively proved. From the west end of the cut, a tunnel was driven N. W. toward the railroad, passing through a thick bed of clay, which was once considered the top covering of the ore, but beyond which this tunnel passed through 50 feet of wash-ore before reaching an ore largely mixed with clay, in which its continuation was abandoned. This tunnel was not open for inspection when visited, and for this information I am indebted to Mr. S. R. Still, the mine superintendent.

From the south side of the cut, and nearly opposite the plane, a tunnel has been extended in a S. E. direction for 230 feet and would presumably pass directly across the bedding of the ore. When first seen in October, 1886. this tunnel was only 180 feet along, and was mostly in ore all the way from the open cut, some blue clay showing at the face and in occasional masses through the ore body. This clay also showed in two side drifts driven at right angles to the main tunnel 190 feet westward and 30 feet eastward, about 50 feet from the entrance, and at that time the appearance of the ore-faces was not very favorable, the ore seeming to rise in the tunnel going south-eastward and admitting of dark blue clays to fill up the tunnel space. Recently the extension of this tunnel to 230 feet has not been productive of very much better results, although ore has been found to a greater or less extent through the additional 50 feet, with a wavy structure and very irregular. Moreover, the visible ore seems to be largely confined to the west side of the gangway, very little showing on the opposite side, which is mainly in dead clays. It would appear that the tunnel is fairly trending on the course of the bed at this point, and it is extremely doubtful if the entry, as at present located, has at all demonstrated the thickness of the bed. Much of the ore in the tunnel is very dense and holds considerable amount of flint, and the material exposed in these cuts would hardly average more than one-third in the washer unless very carefully mined.

The superintendent stated that on May 16th, 1887, he passed 76 cars of material to the washer from which he

obtained 46 of clean ore. This material came from the bottom of the open cut; but no such average record can be expected from any mine in this valley unless it be one mining only the hard lump-ore, which, perhaps, will occasionally run ton for ton. The central part of the pit, now being sunk to a lower level, shows a diameter of about 75 feet, and when last seen was about 15 to 20 feet below the general level of the cut. No great mass of lump-ore had as yet been developed in this part of the pit and the material uncovered was not at all attractive, except in a limited part of the west face, being quite black and largely mixed with impure barren clays. The south face shows about 4 feet of an accumulation of wash mud from the old workings, three or four feet of abandoned ore, and clay beneath it, two feet of white and yellow, lean clays and six to eight feet of wash-ore, with massive pieces at the bottom.

Analysis of Laurel bank No. 1 ore.

Metallic iron,	38.100
Metallic manganese,	7.226
Sulphur,	.022
Silicious matter,	20.220
Phosphorus,	.169
Phosphorus in 100 parts iron,	.443

The entire product of the mine in May, 1887, averaged 50 to 60 tons a day, taken from this open cut. In the north-eastern end a water drain was driven in a northerly direction, passing beneath the railroad to the creek beyond. Mr. Still claims that this tunnel passed for 300 feet through wash-ore, which, if really the fact, would make a compressed synclinal basin at this mine, overturned a little south of the present cut, and with nearly level dips in its northern arm. This doubling of the ore body would account for the extent of the deposit in the tunnel leading south from the cut, while the drain just mentioned may not pass out of a single ten-foot layer of the ore-bed.

According to Mr. King, the lump-ore in Laurel No. 1 bank gives 3.50 per cent. of manganese and about .150 per cent. of phosphorus, with 42 per cent. of metallic iron; so that by using this ore the resulting pig metal can be made

with 50 per cent. less of phosphorus than that worked in Pine Grove No. 1. The Pine Grove furnace depends largely upon this ore for the production of their neutral pig iron, the present practice being to mix about 50 per cent. of Laurel No. 1 with the softer brown-hematites near Hunter's Run, which are practically free from manganese. An average mixture of ⅔ Laurel and ⅓ Crane or Lehman ore gave a pig with the following analysis, car wheel iron with ⅜ inch chill:

	McCreath.	*King.*
Silica,	1.426	1.328
Phosphorus,	·305	.280
Sulphur,	.009	.019
Manganese,	2.722	2.788

Laurel bank No. 2.

This lies about 300 yards S. E. along the flank of the same hill upon which Laurel No. 1 is located, but rather closer to the mountain and evidently carries a larger percentage of sand and clay mixed with the ore than the first bank. This mine was vigorously worked from 1878 to 1881 during the activity in the iron market; but it is now definitely abandoned and its tracks and machinery torn up and removed elsewhere. The cut is about 200×100 feet superfical measurement and is filled up with barren yellow clays holding a fair amount of liver-colored brown-hematite, said to be neutral in character. The spur upon which this opening is located begins to expire at about this point and the opening is pretty well around its N. E. end.

When actively mined the ore-deposit is said to have shown a very flat dip and it is probable that this ridge marks the line of a short anticlinal axis. Lump-ore is said to exist in considerable masses in the bottom of the cut divided by four feet of clay from the top wash-ore which varies in thickness from 12 to 20 feet. Everything is very much washed now however, and this bottom ore is entirely concealed. What there is showing in various parts of the cut and lying around the tram-road seems to have a more compact character than that of Laurel No. 1, and the latter more so than the Pine Grove ore.

For at least a mile N. E. (down the creek) there are no further developments, nor has much ore ever been found in any test pits through this interval; but from here for probably a mile and a half along the mountain on the north side of the creek and railroad there are probably a half a dozen old openings none of which are worked at present, but from which a considerable amount of ore has been taken in past times.

The first of these (nameless) situated quite close to the South Mountain railroad at Henry Clay station, is a small cut 20×20×6 yards showing absolutely nothing and lying on the crest of a long gentle slope of Potsdam sandstone and from which probably three thousand tons have been mined. No ore is visible now except some few large boulders protruding from the greatly washed faces and largely surrounded by barren clays. All the ore taken from this cut was apparently washed elsewhere as there are no signs of there ever having been machinery here. Some little outcrop shows sparingly to the west of this pit along the Pine Grove road but no evidence of its ever having been properly tested are now to be seen.

Analysis of Laurel bank No. 2 ores.

Metallic iron,	40.600
Metallic manganese,	3.069
Sulphur,	.034
Silicious matter,	19.260
Phosphorus,	.491
Phosphorus in 100 parts iron,	1.209

Lanigen Bank.

This is about 125 yards east from the last opening and on the same hill slope. Though this was a much larger operation showing an excavation 40×30×10 yards the ore is no more satisfactorily exposed here. The sides of the pit are completely covered with a wash of Potsdam sandstone and yellow clay down to the bottom of the cut, which is filled with water to within 30 feet of the surface; and the merest appearance of ore in small boulders shows in some individual spots. There has been probably 15,000 tons of ore

mined here, and Mr. King of Pine Grove states, that when abandoned, the bank showed an excellent exposure of lump-ore beneath the present water level. The ore was mined by an inclined plane from the north side of the cut, which is in a very dilapidated condition at present, and the best exposure, a fine wash-ore, lines the north face of the bank east and west of the plane. The stripping is fully 15 or 20 feet thick, and even the wash ore said to exist beneath this overburden is concealed for 10 feet above water-level by the mud which has washed over the ore-faces.

Analysis of the Lanigen bank ore.

Metallic iron,	36.850
Metallic manganese,	1.513
Sulphur,	.024
Silicious matter,	29.970
Phosphorus,	.320
Phosphorus in 100 parts iron,	.868

Seyfert and McManus mine.

This is the next opening, within sight of the Lanigen bank and about 100 yards east of it. Very little additional information can be given of this cut, which although somewhat more extensive, shows practically the same features as are exhibited in the two banks already described. The best showing of wash ore is on the north side where as might be expected it is largely due to its being away from the mountain wash; but even here it is largely mixed with small sandstone boulders. This mine is also abandoned and filled with water; but its appearance prior to abandonment is stated by Mr. King as being quite as favorable, if not more so than that of the Lanigen bank.

Analysis of the Seyfert and McManus ore.

Metallic iron,	41.350
Metallic manganese,	1.253
Sulphur,	.024
Silicious matter,	22.000
Phosphorus,	.666
Phosphorus in 100 parts iron,	1.610

Henry Clay bank.

This lies about 50 yards still further east; filled with water to within thirty feet of the surface. It shows a cut 150×60 feet wide and still shows some good brown-hematite ore, largely mixed with a silicious stripping, along the north face. In all of these banks the best ore is now entirely covered up the openings having been abandoned when the lump-ore was met with. They all occur on the flat plateau gently rising southwards up the flank of the main mountain, and are largely accompanied by quartzite and sandstone; no limestone showing anywhere.

Analysis of the Henry Clay ore.

		Lump ore.
Metallic iron,	35.850	50.250
Metallic manganese,	2.247	.072
Sulphur,	.032	.007
Silicious matter,	31.890	10.650
Phosphorus,	.184	.513
Phosphorus in 100 parts iron,	.513	1.020

Diven, Koontz and Meyers banks.

These are two additional openings in the next two miles down the creek. They were small and the amount of ore taken from them insignificant and have been apparently abandoned for a number of years.

Grove bank.

This, near Hunter's Run station, may be similarly described. It adjoins the Lehman No. 2 tract on the north side of creek. The analyses of these three last ores, from samples secured in 1881, show:

Analyses of the (1) Diven, (2) Koontz & Meyers, (3) Grove ore.

	(1.)	*(2.)*	*(3) Wash ore.*	*(3) Lump ore.*
Metallic iron,	45.150	34.500	36.100	46.900
Metallic manganese,	.353	.453	1.578	1.282
Sulphur,	.014	.041	.015	.003
Silicious matter,	14.970	30.840	28.620	13.370
Phosphorus,	.774	.235	.915	.809
Phosphorus in 100 parts iron,	1.714	.681	2.534	1.725

Analysis No. 2 of the Koontz & Meyers bank was made from a sample of ore prepared by the so called "dry washer;" so that the analysis practically represents the ore unwashed.

The Grove lump ore sample was selected by Dr. E. A. Grove.

East of the Grove bank and well up the southern flank of the first ridge, north of the creek and railroad, there are several important ore banks in active operation during the spring of 1887 and which furnish practically nine-tenths of the ore now mined in the Mountain Creek valley. They are all located on land belonging to Mr. Lehman, who has divided his tract into several small areas and leased them to various individual operators.

Chestnut Hill Ore bank.

This is the most westwardly of these openings, situated about half a mile north of the railroad and probably a mile and a half from Hunter's Run station. When first visited in the fall of 1886 the company had just begun to drive a tunnel from the face of the hill northwards to meet the ore-bearing formation which crops abundantly at a little higher elevation along the flank of the mountain. This method of developing these brown-hematite ores is now being largely adopted in order to avoid the necessity of removing a large amount of stripping and at the same time provide for a drainage and a ready movement of the wash ore material. The system is undoubtedly a good one, especially where the topographical circumstances are such as to warrant the construction of a tunnel without having one of too great length.

The outcrop is worked as formerly, the tunnel being only designed to reach the bed at a depth of 30, 40 or 50 feet as the circumstances will permit, from which a stope is driven up to daylight, thus providing a convenient method of loading the good material while removing the overburden by means of horses and carts from the surface workings. When necessary, any mine so opened can be worked by means of underground drifts and gangways to the right or left of the main entry whenever the surface workings have

become too extensive to handle the material quickly and economically. All the wash material passing through the shutes directly to the ore cars in the tunnel is carried to the washer without further handling, which in this way is not burdened with the necessity of cleansing a great deal of material which hardly pays for washing and greatly limits the production of the mines, especially where wash water is so scarce as is usually the case in the South mountain operations. At the Chestnut Hill operation the ore body has been tested by a number of 30 to 40 feet pits to the east and west of the tunnel, and it is expected that they will soon be able to erect an additional washer to the west of their present plant. The company have likewise wisely erected a first-class pump on Mountain creek which will insure them an abundant supply of water for cleansing their ore and perhaps become a source of revenue from other operations on the mountain using the surplus water. The length of the tunnel here is about 400 feet; well timbered and with an evenly-graded road and good drainage. In the early part of May the company were just preparing to wash their first ore, having been principally engaged in removing a top stripping which occurs here from 15 to 30 feet thick. This stripping had then been removed for a length of about 125 yards and the top ore exposed beneath it did not seem to be exceedingly rich. There can be no doubt, however, of the existence of a large and handsome body of ore at this place and the present tunnel will secure a working face of about 35 feet. The tunnel mouth is about 110 feet above the level of the railroad and enters the ore-bearing clays first at about 130 feet and continuing through them for 230 feet additional to the end. This 230 feet by no means represents commercial ore material, being rich and lean alternatively, with the usual characteristic changes along the line of strike presented in all brown-hematite ore banks. Most of the lump ore is found close to the mountain, which, considering the method of its formation, was to have been expected, just as the lighter and small lump ore is found mixed with the variegated clays to the front of the lump ore and away from the mountain. In any av-

erage of these ore-bearing clays along the mountain flank it cannot be assumed that there will be obtained more than one cubic yard of clean wash ore from ten cubic yards of wash material; but the ore is rich (47 to 49 per cent.) in metallic iron and very low in phosphorus (.08 to .1 per cent.) and consequently is highly valued in a region which generally furnishes ores almost too cold-short for the market open to them. According to Mr. J. L. Boyer, superintendent, this company holds by lease about 3000 feet along the outcrop, nearly of which has been tested by shafts and small pits. All the ore mined here is destined for the Chestnut Hill furnaces.

Dunbar mine (*R. Boyer*).

This is a new operation immediately adjoining the last described on the east. It is opened by a shaft 59 feet deep, 9 feet of which provides for a sump to catch mine water. The main gangway had been extended about 220 feet north from the bottom of the shaft in May, 1887, the first 140 feet being through ore-bearing clays but the last 80 feet entirely through barren material. One drift 150′ long had been driven westward from a point about 60 feet from the bottom of the shaft. This entry was driven all the way upon ore material; but the general character of it was lean, the ore occurring in small plate-like masses thoroughly mixed with buff-colored clay, and not washing more than one in ten. At the end of the drift the ore lay pretty well to the top of the entry and was found *dipping very gently to the south-east*, quite the reverse to the condition of affairs as exposed along the main tunnel and the side drifts further back towards the mountain, where the ore is *practically vertical*, varying, as the whole mass swells or contracts, between 70° north and south. Two drifts have been extended eastward from the main tunnel at 100 and 140 feet from the shaft, and respectively 72 and 60 feet long at the time of inspection. The ore bodies developed in these drifts were exceedingly irregular and of no great thickness. The ore

is lemon-colored and platy, and from its large admixture of clay it requires an exceedingly large amount of water to cleanse it. It is doubtful whether this company have adopted the most economical means for opening their property, although their plant is well equipped for the small output (12 tons) now secured. The main tunnel seems to have cut three distinct ore beds, none of them over two or three feet in thickness and separated from each other by an immense amount of barren clay. It is true that a week's development may result in the finding of an important body of ore in any part of this mine; but the large amount of lean material the company are compelled at present to lift from their mines and pass through the washer would seem to largely counterbalance the good quality of the ore, if not the price obtained for it.

Crane Iron Company's banks.

These banks operate also upon a lease from Mr. Lehman, and are situated about a quarter of a mile east from Dunbar, and at about the same elevation on the hillside. This company works in an extensive open cut beneath the base of which they have recently run a tunnel extending back from their washer, which receives the bulk of the ore-material mined from various parts of the irregular cut, while the overburden is carried off by another track leading out of the mine at a slightly higher elevation. The stripping here, under the most favorable circumstances, amounts to about 20 feet, while toward the mountain where their best ore is found, it is simply enormous and consists mostly of a sandy blue and white clay.

The output of ore in the fall 1886 was about 30 tons a day which was then divided betwen Columbia, Pine Grove, Dunbar and Newport furnaces. In the spring of 1887 this output was probably increased, owing to renewed activity in the iron market, and there is no reason why a much larger tonnage could not be obtained as wanted except for the fact of the immense amount of work which must be necessarily done in cutting the mountain back to obtain the bottom ore. The present ore-body

seems to lie largely in that direction, and is apparently dipping at a very steep angle *into* the hillside *northward*, although at deeper levels it may be found to turn and dip normally to the S. E. A shaft to the east of the present cut passed through 50 feet of ore, and a cross-cut to the north or into the mountain passed fully as far through ore and clay. The south side of the cut exhibits largely yellow barren clay and the immense waste heap along the public road will give a fair idea of the amount of dead material this range of ore-bearing clays will furnish. The whole excavation may be 350 feet long and about 40 feet wide; but it has been very irregularly opened to different levels and terraces along the bottom. The floor of the cut is being worked down to the level of the tunnel at the same time that the face against the mountain is being stripped, so that in the course of a few months the company may be prepared to make a large tonnage here once that the mountain wash has been removed. If the ore still continues to dip to the N. W. at the level of the tunnel, it is a question whether it could not be more economically worked by underground drifting, especially if, as seems probable, the ore near the mountain is as rich and free from clay as the open cut indicates. The old opening can still be worked down 20 feet below its present floor, so that a large tonnage can be secured without advancing any further towards the mountain. The *stratification of ore and clay in bands* and irregular masses is very marked in this bank, and the wavy structure of the whole ore-mass almost defies an interpretation of its proper dip.

Lehman bank.

This (leased by the Pine Grove furnace) is on the same range of ore, about a quarter of a mile still further east and nearer Hunter's Run station. The country between this opening and the Crane operation has been fairly tested with pits and with the usual barren intervals it is quite probable that the deposit of ore is continuous between both openings. When first visited, in October, 1886, this large mine was entirely idle for want of proper water facilities, a bore-hole

near the engine house sunk for water having failed to produce a sufficient quantity for the mine, although it is said to have developed the presence of a large body of ore through which it passed for 340 feet. Beneath the ore the bore-hole passed into 40 feet of blue clay, 30 feet of white clay and 25 feet of "mountain clay" to the Potsdam sandstone rock, having a total depth of 435 feet*. Operations were renewed in the spring of 1887 for the purpose of supplying this very desirable ore to the Pine Grove furnace, although the amount being mined was not great. The pit is about 250 feet long and 50 feet wide, and shows the same general character of ore and variation of clay as at the Crane mine just described. In some portions of the cut this ore-material will wash nearly one-half; but the average of the whole bank will not perhaps yield more than one-eighth or one-tenth, as everything mined is passed through the washer. All the material is raised by means of an inclined plane, this being the only mine on the mountain adopting that system of working, which, however, was instituted some years ago when the mine was first opened. No solid lump-ore has been worked at this point, the deposit being largely fine lump mixed with yellow, blue and white clays, all dipping steeply S. E., although as before stated, the dip is exceeding irregular and cannot take much effect until at a very considerable depth below the present opening. The striking of Potsdam sandstone in the well, however, is certainly evidence of its final dip to the south-east, underlying the ore. A heavy white clay shows on the western extremity of the cut, similar to that seen at the Crane bank. The quality of the ore is very good for this class of deposits, as evidenced by the analysis below, and in May, 1887, about 25 tons a day were being sent to Pine Grove furnace for mixture with Laurel No. 1 ores.

*The record of this well is very instructive, for it cannot be supposed that the real thickness of ore passed through will at all approach the figures given above; but it would rather suggest the structure at this point to be nearly vertical if not overturned, and it is far more likely that but a comparatively small portion of the bed was pierced until near the bottom of the boring.

Analysis of the Lehman ore.

Metallic iron,	43.950
Metallic manganese,	.124
Sulphur,	.046
Silicious matter,	18.860
Phosphorus,	.087
Phosphorus in 100 parts iron,	.197

In a direct continuation of this line of ore-deposit from Pine Grove furnace to Hunter's Run, there is another series of ore banks on the east side of Mountain creek which are situated similarly, both geologically and topographically. The mountain ridge separating Mountain creek from the main valley expires about 2 miles east of Mt. Holly. Between that point and the Paper mills, the ore banks are all located in the shallow valley between this ridge and the next parallel spur of the South mountain sto the south; but upon the expiration of the north spur, the openings all hug the north base of the rear spur, the ferriferous Potsdam slates carrying the ores encircling the ends of each successive spur as it sinks beneath the plane of the valley eastward.

Consequently the same general character of ore found along Mountain creek is exposed in the shallow valley east of the Paper mill; along the base of the mountain south of Boiling Springs and finally as far east as Dogwood Hollow, west of Dillsburg.

Mt. Holly (Medlar) Hematite bank.

This is situated on the base of the north flank of the *Second mountain* south of Mt. Holly, and about one hundred and fifty yards up this flank from Mountain creek and the Gettysburg & Harrisburg railroad. There are two very extensive open cuts here, now entirely abandoned and filled with water. Both lie just inside the gap and close to one another. No. 1 pit, the most eastern and lying closest to the pike, is about 150 yards east and west, 75 yards north and south, and of unknown depth, filled up to within 30 feet of the surface. It still shows a fair amount of wash-ore along the south side, where the ore rises close to the surface and is kept comparatively clean by surface wash-

ings. Elsewhere the ore is deeply covered with clay and sand wash. In character the ore seen was a close-grained brown-hematite, some little of it being bomb-shell ore, occurring in large, cellular lumps, filled with clay. All the water for washing purposes here was obtained from Mountain creek.

No. 2 pit.

This is a little further to the west, is about 200 yards east and west and varies from 60 to 100 yards north and south. The best ore seen here was along its northern face, west of the old washer, though there is a fair exhibit in the extreme eastern end and in isolated patches along the southern side facing the mountain flank. It is claimed that there still remains a large amount of ore in this cut, and as much as 1,000 tons a month have been mined here in past times. The ore from both pits, however, is rankly cold-short, and this fact, together with the expense of mining and the low price of ore, has led to the abandonment of both operations perhaps for many years to come. It is estimated that at least 100,000 tons of ore have been taken from these cuts, most of which went to the furnaces at Harrisburg, where it was used with a mixture of Cornwall magnetic ores. The character of ore from these banks is shown by the following analyses:

Analyses of the Mt. Holly (Medlar) ore.

	(*a*)	(*b*)
Metallic iron,	38.250	48.500
Metallic manganese,	2.730	.727
Sulphur,	.005	.006
Silicious matter,	23.550	11.270
Phosphorus,	1.373	1.619
Phosphorus in 100 parts iron,	3.589	3.338

Sample (*a*) consisted of about two-thirds lump and one-third wash-ore.

Sample (*b*) represents the dark brown cellular lump ore exposed in 1881 in the north-east end of the bank and analyzed separately.

North-east from Mt. Holly Paper mill and on the eastern side of the pike, a ravine heads up on the south side of the first mountain, along which there is a fair amount of brown-hematite exposed in various old openings and small test pits. The horizon of all these ores is practically the same as that of the Mt. Holly banks.

Strickler bank.

This is located in the ravine, between the first and second mountains, and a good mile east of the Mt. Holly Paper mills. It may be further located as three miles south-west from Boiling Springs. The first mountain, or outer ridge of the South mountain, is beginning to die away at this point, and descend beneath the limestone plane, just north of the bank. The opening is an oblong-shaped excavation 70 x 40 yards and about 15 feet deep to the level of the water which now effectually conceals the ore below. It is reported that the lump and wash-ore here occurs first at just about the level of the water, under some 15 feet of stripping; but the bank has not been worked actively for many years, and in its present condition it is impossible to state anything about the character of the ore. The total thickness of ore developed here is put at about 40 to 45 feet, and the output may possibly have reached 30 or 40,000 tons.

Analysis of the Strickler ore.

Metallic iron,	42.950
Metallic manganese,	.093
Sulphur,	.027
Silicious matter,	18.960
Phosphorus,	1.392
Phosphorus in 100 parts iron,	3.240

On the road to this point from Mt. Holly, several recent test pits from 15 to 30 feet deep, have been put down in search of ore; but to judge the results by the character of the material thrown out from them, no very great success has been attained. From the deepest pit, about one-quarter mile west of the Strickler bank, a few bucketsfull of small lump-ore have apparently been picked from the large covering of white and buff clay which is passed through from the surface down as far as the eye could reach. All of the ore near here contains large quantities of both manganese and phosphorus.

Pepper or Old bank.

This lies about three-quarter miles E. S. E. of Strickler's, and near the head of a little limestone valley which extends

around a prong of the South mountains, about two and a-half miles S. W. from Boiling Springs. At this point there would seem to be sufficient water for washing purposes at least, although the same causes which have led to the abandonment of so many other operations in this vicinity, have been in force here. A siding of the Harrisburg & Potomac railroad extends into the washer of this mine, which is situated about 125 yards from the bank. The latter shows a narrow and deep trench filled with water to within forty feet of the surface, whose dimensions are roughly 125 × 50 × 15 yards deep. The eastern end of the cut, towards the torn up washer-tracks, shows a buff clay and sand, with a fair amount of wash-ore extending east from the foot of the plane; to the west of the plane there is a barren streak of white clay 12 feet wide, while the balance of the mine varies greatly in appearance between good and indifferent. Most of the cheap ore has been already won, and not altogether to the advantage or the appearance of the mine. Many of the loose pieces of ore between the bank and the washer have a dark black color and are evidently manganiferous. The whole place has a barren, deserted appearance, and there would seem to be no intention on the part of the mine owners to renew operations in the immediate future. Ten or fifteen years ago this bank was largely worked to a depth of 75 feet, and test shafts had been sunk 25 feet beneath the bottom of the cut, making the total thickness of the ore-bearing clays at this point 100 feet. The ore was then used at Boiling Springs furnace, with mixtures of the limestone ores and occasionally magnetic ores. The iron then made was of excellent quality, and was sold for gun metal purposes. It is entirely reasonable to infer from the size of the excavation that at least 100,000 tons of ore have been taken out prior to its abandonment. The character of this ore is fairly shown by the following analysis:

Analysis of the Pepper or Old bank ore.

Metallic iron,	45.100
Metallic manganese,	.230
Sulphur,	.020
Silicious matter,	21.020
Phosphorus,	.176
Phosphorus in 100 parts iron,	.390

Ege Bank (Big Bank).

This mine of the Philadelphia & Reading Coal & Iron Company lies about two miles nearly due south of Boiling Springs, and is reached by a branch line from the Harrisburg & Potomac railroad. In company with the Superintendent, Mr. A. Derland, this immense excavation was visited in the fall of 1886, and to him is largely due the compilation of facts which follow. For, inasmuch as this opening has practically been abandoned for the time being, many of the working faces and old shafts were filled in and it was with difficulty that several of them were located at all. In spite of the abandonment and the general disintegration throughout the cut, the locality is a very excellent one to study the character of these mountain ores, and is a good illustration of how large a quantity of ore any one of these large banks has been able to furnish.*

The ore-bank shows an excavation probably 500 yards long, and possibly averages 75 yards in width, although in shape it is excessively irregular and its width varies at nearly every 100 feet. In depth likewise it shows many changes. At the eastern end, it is some 400 feet wide, and fully 40 feet of the solid lump-ore lines the sides and bottom of the deep central oval pit, some 60 yards long and 40 yards wide. To the east end of the bridge which spans the excavation a little beyond this deep cut, the show is not so attractive. Barren buff clay hummocks are visible in several places, and the sides of this portion of the cut are greatly washed in.

*The quality here, however, does not seem to be up to the requirements of the iron masters, and even the Katharine furnace at Boiling Springs at present uses ore from Sheperdstown, Virginia; Cornwall, and other banks a considerable distance up the valley, in preference to buying this ore right at its doors.

Toward the west end of the cut the exposure of ore is partially covered up with loose wash material; but the bed has been followed there, shafted upon and drifted, swelling and thinning in places, but holding a fair average thickness of 25 to 40 feet and everywhere dipping steeply S. E. At the extreme west end the deposit thins up to a mere plate, and the cut entered a thick bed of yellow clay.

Test pits, 30 feet deep, were sunk further west without finding any ore, so that the present cut fairly limits the extent of the commercial ore-territory at this particular place. Beneath the present level of the main cut, a tunnel has been driven in an irregular manner, curving along the north edge of the ore, always with the view of keeping the main ore-body to the south and developing it by cross drifts. The line of junction is a distinct white clay, separating readily from the ore, and the occurrence of this material permitted of the extension of the tunnel without too great an expense.*

Along the north edge of the cut, frequent pockets of the manganiferous iron-ore are found whose decomposition gives rise to a dark sooty clay soil, showing prominently in spots through the body of white clays which usually overlie the ore. Mr. Derland reports that toward the east end of the mine, the ore mass swelled to fully 400 feet across; but while there is some ore still in the bottom most of the cheap ore has been removed and that which remains in sight is considerably broken up with streaks of tough and barren clays.

The general appearance of the bank would seem to suggest that the larger portion of the wash-ore variety has been removed and that which is still to be sought, lying at the bottom of the mine, is almost entirely lump-ore, difficult and expensive to mine, and not so pure as that of the wash-

*Mr. Derland reports that the north edge of the ore exposed in this cut was found to curve sharply to the N. W., as if formed by a compressed anticlinal, and the doubling arch thus produced does not seem to have extended up as high as the upper tunnel; for while no ore was found in it, a lower tunnel driven from the washer southward through the hill to the ore-bank, met with a considerable body of ore 30 to 40 feet north of the present excavation.

ore. No. 3 tunnel at the east end of this mine is 775 feet long, extending in a general south course from the railroad through the hill to the ore-bank and designed both to drain the lower portions of the excavation as well as to avoid the necessity of raising these ores by an inclined plane. This tunnel was driven for 650 feet before the ore was reached, which is further evidence of the S. E. dip of the ore-bearing clays at this point, inasmuch as at higher levels they occur fully 50 feet nearer the railroad.

Tunnel No. 2, at the west end, was 450 feet long, mostly in lean clays, with here and there a spot of ore-territory. A shaft located close to the line of this tunnel and not far south of its mouth, was put down 35 feet, and struck an encouraging body of ore at a slightly lower level than the line of the tunnel; but two others near by, 20 and 25 feet deep, went entirely through barren material, which fact fairly illustrates the variable nature of the ore deposit. A shaft 32 feet deep in the bottom of the main cut and towards its western extremity, is all in good lump-ore; and in a drift run from this place N. W. 160 feet to connect with the tunnel, a fair proportion of wash-ore was found, but largely mixed with clay.

Further north a small shaft was put down from the floor of this drift and a "monkey drift" driven east and west, which developed a total width of 75 feet of lump-ore. About 31,000 tons were taken from the hole in the center of the mine, where the ore occurred almost entirely free from clay. The mountain side of the cut still shows quite a solid face of ore. None of the developments have been carried far in that direction owing to the excessively steep character of the side hill, and the dangerous stripping that would have to be done to secure the ore by means of an open cut.

The massive nature of the deposit on this side of the excavation is well seen in the oval pit in the center of the bank, from the bottom of which a tunnel has been driven eastward along the strike of the ore, all the way through massive ore material. The north side of this lower cut does not present such a solid face of ore, and shows an

inclination to a north dip, suggestive of the presence of a tightly folded anticlinal such as has been already described toward the western end of the main opening. The wash-ore forming the top of the deposit, occurs pretty generally through the cut; but wherever the lump-ore is struck, it is found to take the form of a wedge, thinner on the north than on the south side, and reported as thickening on the dip toward the mountain.

Every variety of ore has been taken from this bank, and records for several years prior to the last work done here in 1884, showed the wash-ore to yield about one ton for each cubic yard of material removed. From the central cut, where most of the lump-ore is now exposed, the yield was much greater; 30,000 tons as already mentioned, having been removed from this place. The bank never yielded more than 35,000 tons a year and has therefore always netted a loss to the proprietors who originally leased it for 99 years on a fifty cent royalty and a minimum production of 50,000 tons a year.

All along the north face of the opening, frequent deposits of the black manganiferous clay are met with, and they fairly limit the productive portion of the mine in that direction not only here, but elsewhere in the mines in this vicinity. Toward the east, the whole deposit shelves up, where the ore has been followed up and over a limestone (?) wedge 160 feet thick, and re-opened beyond in a small pit from which a considerable amount of ore was mined.

The numerous shafts sunk still further east have been only partially successful, although the deposit is generally supposed to be persistent to the Beltzhoover bank, 3,700 feet distant. The gangue material accompanying these ores, and especially that seen mixed with the material thrown out of the trial pits, is frequently a greenish, talcose slate, called "soapstone" by the miners, many of whom state likewise that the base of the ore-bearing clays is a reddish slate, beneath which no ore, but occasionally barren white clay, is found. Some 12,000 tons of lump and wash-ore are piled at the washer of the Ege mine, where

there is also a considerable amount of fine shot ore, largely mixed with quartz. The character of this ore is as follows:

Analysis of the Ege bank (Big bank) ore.

	Lump ore.	*Wash ore.*
Metallic iron,	34.350	32.150
Metallic manganese,	4.539	3.112
Sulphur,	.022	.022
Silicious matter,	26.370	28.800
Phosphorus,	1.079	1.059
Phosphorus in 100 parts iron,	3.141	3.293

Beltzhoover bank (P. & R. C. & I. Co.).

This lies about 3,700 feet east of the Ege opening, measuring from washer to washer. In many particulars this opening presents the same characteristics as the larger opening just described. The excavation is 450 × 60 × 10 yards, with an outlying circular open cut to the south, cut off from the main ore-deposit by about 200 feet of stiff yellow clays, andhaving dimensions of 50×50×8 yards. This latter opening has not been worked for five years, and no ore has been mined in the main bank for the last three years.

Geologically the deposit is in every way similar to the Ege ore, occurring in the same rocks, associated with similar clays, and in every respect a virtual continuation of that deposit along the flank of the mountain. There is one conspicuous difference however, inasmuch as the ore body *dips distinctly away from the mountain* N. and N. E. with angles of from 40° to 50°.

The ore body here is not more than 40 feet thick, and a number of shafts put down along the south edge of the excavation along the mountain side all passed through barren tough clays. Variegated colored clays likewise overlie the ore on the north side and are largely associated with the black manganiferous variety. The ore body, massive below and carrying the wash-ores on top, is underlaid by a strip of reddish sandy slate, below which no ore is found. About 50,000 or 60,000 tons may have been taken from this opening, of which amount 3,500 tons of wash-ore and 1,000 tons of lump ore still remained at the washer when visited in November, 1886.

The original opening was made toward the west end of the cut, a little south of the washer, and of no great depth. Afterwards a slope was put down to a cut 30 to 40 feet deep, at the bottom of which a shaft 32 feet deep passed entirely through lump ore, but ore having a steep north dip.

A good deal of water filled the central portion of the bank, so that the character of the ore along the bottom could not be seen. The north side of the cut is generally lean; the eastern end of the cut shows some good ore on the S. E. side with a tendency to curve southwards around a spur of mountain, but thin and largely accompanied with barren clay. Several (reported) good shafts induced the company to drive 200 feet south from this cut through stiff yellow clays to the rear opening; but the amount and character of the ore obtained here was on the whole discouraging, and hardly paid for the work necessary to reach it.*

From the old *Crockett bank* lying further west up the hollow between the main mountain and the spur already spoken of some ore was taken and some few test pits can still be seen along the base of the mountain in this ravine. The analysis of the ore from the Beltzhoover bank yields the following results:

Analysis of the Beltzhoover ore.

	Lump ore.	*Wash ore.*
Metallic iron,	40.900	36.950
Metallic manganese,	2.594	1.347
Sulphur,	.030	.029
Silicious matter,	19.290	24.360
Phosphorus,	.909	.740
Phosphorus in 100 parts iron,	2.222	2.003

Leidig and Hoffer bank.

This is a small operation situated in the cave on the *south* side of the spur upon which the Beltzhoover mine workings are located and about 3½ miles south east of Boiling Springs. No great amount of ore was ever mined here, and the bank

*The dip of the bed at this point is much more gentle and is decidedly eastward, which is further confirmation of the ore-bearing slates folding over a dying anticlinal spur as before mentioned. Bold outcrops of Potsdam sandstone create a sharp crest line in the hill immediately to the south, where they are known as the "White Rocks" and dip S. E.

was abandoned and concealed when visited. The character of the ore is shown by the following analysis:

Analysis of Leidig and Hoffer Ore.

Metallic iron,	48.700
Metallic manganese,	.245
Sulphur,	.025
Silicious matter,	15.090
Phosphorus,	.380
Phosphorus in 100 parts of iron,	.780

Dogwood Hollow mines.

About three miles west of Dillsburg, in York county, there is a group of hematite ore-banks in Dogwood Hollow, a rather narrow valley holding No. II limestone in the trough of a synclinal, and bounded north and south by spurs of the South mountain in which the Potsdam sandstone and slate rocks outcrop. The valley contracts gradually as Dogwood run is ascended; and finally the two spurs unite, forming a broad plateau of the Potsdam rocks from the surface of which the higher limestone measures have been eroded. Very little limestone is to be seen through the valley except near its mouth; but that rock undoubtedly makes the floor and is only concealed from sight by a surface wash from the mountains on either side of it.

The mines so far opened all lie on the north side of the valley and on the flank of the mountain, and the ore is everywhere associated with the buff-colored clays, arising from the decomposition of the upper Potsdam slates. In many respects, these ores present the same characteristic features as those occurring on the mountain flank north of Hunter's Run and Mountain creek, where the same measures outcrop in a precisely similar manner and present the occurrence of ore mixed through a more or less barren area of clay.

Quite a considerable amount of ore in the aggregate is raised from these Dogwood Hollow mines and hauled by carts to Dillsburg, where they are re-loaded into cars and distributed to the general trade. They are not apparently

any richer in iron than many of the banks now inactive and they are certainly not as advantageously situated as some; but their comparatively low phosphorus has continued their existence beyond the life of ore banks capable of furnishing, perhaps, more cheaply mined material.

Dogwood mine (McCormick & Co).

This is the first opening met with going west from Dillsburg along the public road. No work has been done here for over two years and at present its sides are completely washed in and the ore-faces effectually concealed. The excavation is quite extensive, but the ore seen was quite lean. The dimensions of the cut are roughly, 125 × 60 × 40 feet, and an old shaft sunk in the western end evidently extended this depth. The mine is generally considered however to have been pretty well worked out and there is apparently no intention on the part of its proprietors to renew operations at this point. The character of the ore as shown from an old sample taken in 1879 yields as follows:

Analysis of the Dogwood ore.

Metallic iron,	45.500
Metallic manganese,	1.304
Sulphur,	.023
Silicious matter,	16.570
Phosphorus,	.342
Phosphorus in 100 parts iron,	.751

Heck bank.

This mine of Dr. Lewis Heck lies probably 200 yards further west, and in the spring of 1887 was in active operation, yielding about 20 tons a day, about one-sixth of which was lump. This point is fully three miles from Dillsburg, and the ore costs 40 cents a ton to deliver there. The Paxton furnace was then using nearly all the ore mined. The bank is a long open cut, 300 feet east and west, 100 feet wide, and in places 80 feet deep. The washer is located close to the public road from which a short inclined plane extends up the hill to the mouth of a tunnel driven 300 feet long through the flank of the ridge to the ore-bank, which it

meets at about 60 feet beneath the surface. The deepest portion of the working was in the western end, and when visited that portion of the mine was being further cut out and the material hauled up a small incline within the bank itself to the level of the tunnel and from there to the washer. This portion of the bank looked exceedingly well, presenting an 80-foot face of good wash-ore material comparatively free from clay and dipping at an angle of about 80° S. E. Ore was also cut in the tunnel at about 40 feet from the entrance to the open cut, and in the bank itself, is exposed for a width of probably 50 feet additional. Back or north of this wash-ore deposit, excellent lump-ore is said to have been tested by drifts run into the mountain side an additional 25 or 30 feet, beyond which nothing but white clay was found. Quite a heavy stripping occurs on the south side of the cut as well as toward the mountain, beneath which however, the ore is decidedly good, though perhaps the material is not quite so rich as along the north side. The policy of the company is to remove everything from the mine as the work advances, and it is questionable whether this does not require an expenditure of time upon waste material which will be found expensive in the long run. However, the excellent character of the ore-face exposed at the time of inspection would seem to justify this method at this particular point, although it is doubtful whether the claims made as to this material washing one-fourth could be substantiated during any long period of time. All through the bank, but least on this western end, the usual characteristics of clay banks and barren spots occur to mar the otherwise good appearance of the ore, and in a system moving the entire material mined and passing it through the washer, there must eventually result either an exceedingly low tonnage of washed ore and consequent increased cost per ton, or else an improperly prepared ore due to the large excess of silicious matter occurring in portions of the deposit. Only some 12 or 15 men are occupied daily in mining ore and in attendance in various parts of the mine, so that the output at best cannot be very large.

The outcrop can still be worked for about 200 yards west-

ward on this property; but toward the east the bank has been extended almost to the Knaub line where some few developments in pits and small cuts have been made, but no ore shipped. This *Knaub property* is all equipped however for development, and a tunnel driven in to meet the ore.

There is considerable showing of undecomposed slate in the Heck cut, and where this occurs the ore is quite slaty. This especially shows on the south side near the mine track and fairly limits the ore bed in that direction. Mr. J. W. Sheaffer, the foreman, stated that a shaft 100 feet deep from the bottom of the Heck bank passed entirely through good ore, which if true, would tend to prove the steep dip of the ore-bed to be maintained for some depth, although it no doubt eventually dips gently to the S. E. towards Dogwood run.

One pair of 24-foot washers comprises the plant for cleansing the ore and the water for washing comes from Dogwood run. The same engine runs the ore-washer and lifts the mine cars to the level of the tunnel from which point they are taken by mules to the ore-bank. The wash-ore at the washer showed quite an amount of free silica, necessitating hand-picking after coming from the washer; but the clay is not especially tough. An analysis of this ore gave the following results:

Analysis of the Heck ore.

Metallic iron,	44.500
Metallic manganese,	.309
Sulphur,	.025
Silicious matter,	20.850
Phosphorus,	.289
Phosphorus in 100 parts iron,	.649

Brant and Arnold; Markley and Shank banks.

These are two adjoining operations upon property of McCormick & Co., of Harrisburg. Both these parties work under lease, and the tunnel of the Brant and Arnold mine is the dividing line of the two leases.

The *Brant and Arnold* (Old Job bank?) lies perhaps a quarter of a mile west along the mountain flank from the

Heck operation and is opened upon a portion of the same deposit. There is no open working done at this point, the development being entirely through an underground tunnel starting at about 25 feet above the level of the public road and extending in a N. W. direction for over 300 feet. This tunnel first passed through a fair wash-ore at about 150 feet from the mouth, back of which there was fully 50 feet of barren clay material until a second body of ore-bearing clays was met with and continued through the balance of the drift. No one in authority was present to show the different gangways developed, and in those visited upon my own responsibility, no greater thickness than 10 or 15 feet of wash-ore was seen. This wash-ore was very largely mixed with clay material and occurred in strips of a quarter to a couple of inches thick, between which no ore was found. However, all the material mined within this ore-bearing zone is passed through the washer, and while it will not, perhaps, average more than one-tenth, the mine gangways occasionally develop a bunch of rich material, which assists in bringing up the percentage of clean ore won. The dip is steeply to the S. E. and the structure of the ore and clay is very wavy, altering with each yard that the drifts are advanced. As far as could be seen, there would seem to be two beds here, the uppermost *geologically* and the most southern *geographically* being only a few feet thick and streaked with clay; the lower one, nearer the mountain, being much thicker, but holding larger bunches of clay within the ore-material. The gangways were extended to the east and west around an old fall resulting from the surface openings, and on each side of this break, very good material was met with through a distance of probably 80 feet. This is possibly the same bed now being worked at Heck's bank.

On the west side of the tunnel and near its present end, probably 350 feet from the pit mouth, there is an excellent body of wash and lump-ore exposed in a large chamber; but no work is now being done there as it was determined that this body of ore was situated on the Markley and Shank lease.

The whole method of working this mine is very crude and expensive, the cars being pushed into the mine and thence to the various breasts by men. The washed ore looked fairly well and clean ; it is light in color and weight and owing to the large percentage of clay should be expensive to wash. It might be mentioned that some stopes of considerable length have been driven up on the rise of the bed in a sufficient number of places through the mine to warrant the assertion, that there is still a considerable body of ore above the general level of the main tunnel ; whereas the whole appearance of deposit, developed in the adjoining mine, is sufficient evidence of what may be looked for below.

Markley and Shank (*Old Wolf bank*).

This mine was in much better order and showed a more attractive character of ore, although a direct continuation of the same outcrop worked at a somewhat greater depth. This mine was once worked as an open cut ; but at present a shaft 75 feet deep is used for access to the mine. From near the foot of the shaft, gangways have been driven to the east and west, and in them the ore-bearing clays show a dip of only about 30° to the S. E., evidence of the tendency of the steep-dipping ore-beds met with nearer the surface to turn at about this depth to a more gentle S. E. slope.

The western tunnel, leading out from near the shaft, had not been driven far and showed the ore from 4 to 6 feet thick, occurring in thin plates, intermixed with clay seams. The east side gangway showed the same character of material, the drift on this side being driven about 125 feet from the main gangway, the ore showing near the top and middle of the drift, underlaid with clay. At 125 feet from the main tunnel, a cross-cut was turned south for 50 feet which *followed* the ore-bed for some distance. Finally the bed sank beneath the level of the drift but lying very flat At the end it showed 4 feet thick capped with clay ; whereas in the main drift, the same bed was near the top. It is designed (April, 1887) to run a drift northwards to a hand-

some body of ore which was developed in the Brant and Arnold openings, and which will be reached by stopes from this level.

From the shaft to he next turn-table, the main tunnel passed through 130 feet of barren white clay, striking there a second and somewhat thicker bed (10 to 15 feet thick) dipping about 70° to the S. E. Cross-cuts were driven at this point and in April had reached 50 feet on the west side and probably three times that distance on the east. This latter gangway likewise leads towards the massive ore deposit struck in the Brant and Arnold opening. At a distance of 50 feet from the turn-table this gangway was forked, one branch keeping pretty straight for 100 feet, while that toward the mountain was carried about 45 feet, the latter through a good ore-body, along a foot wall of white clay. Stopes have been run up in this bed for perhaps 100 feet and a large amount of material taken from them is said to have washed from one-fourth to one-sixth. The same is true of the right hand fork which was extended through an excellent mass of ore until a break was met with, letting in the surface from an old open cut above, and crushing the underground timbers.

All these gangways are beneath the level of those in the Brant and Arnold mine and the ore seen in the long side-drift did not seem as dense or massive as that exposed in the large chamber above referred to, although it is generally supposed to be the same bed. From the turn-table the tunnel has been extended some 75 feet additional, largely through clay to an excellent body of ore, the thickness of which, however, had not yet been tested. Side drifts were driven on this bed 40 feet westward and 50 feet eastward. All pillars have been robbed in the east side, so that this gangway could be followed but a short distance; but the ore seen was excellent and the bed carries a large amount of massive lump-ore in this part of the mine. A winze had been extended on a 45° rise for 125 feet from the end of this 50 foot drift; but the bed itself at this point is standing nearly vertical. In 1886 some 4300 tons a month were washed at this mine when developments were actively

pushed; but at present the yield is not over 100 tons a month, and the general character of it is shown by the following analysis, which might equally apply to the Brant and Arnold ore:

Analysis of Wolf Mine ore, (Markley and Shank.)

Metallic iron,	40.950
Metallic manganese,	.497
Sulphur,	.032
Silicious matter,	21.100
Phosphorus,	.711
Phosphorus in 100 parts iron,	1.736

Ore deposits in the Limestone belt.

It has been already stated that in addition to a series of fairly persistent ore deposits occurring in the transition slates between the Potsdam sandstone and Siluro-Cambrian limestone formations along the base of the South mountain, there are certain portions of the Great Limestone Valley itself which have yielded more or less iron-ore from an horizon *geologically* higher than those first described.

Probably over a hundred small openings have been made in various parts of the valley in Cumberland and Franklin counties, in different horizons in the limestone measures, and which have furnished a few hundred or a few thousand tons of ore.

As a general thing the total tonnage of any one opening has been small, and the larger number of openings are now entirely worked out and abandoned. Many of them can hardly be detected at present, having long since been filled up and worked over by the farmers.

This class of ores can, in no sense, be considered *persistent*, and no doubt many more such openings could be made were the condition of the iron market or the character of the ore to warrant such development. The chief mines, among the many opened, lie east of Newville and in Franklin county, and they will be briefly described in that order.

Gutthart bank.

This lies about three and a half miles E. S. E. from Newville on the Cumberland Valley railroad, and in the late fall of 1886 was being worked to a small extent for supplying Katharine furnace at Boiling Springs. The ore occurs here largely between walls of limestone, the rock often coming together and squeezing out the ore, while elsewhere spreading sufficiently apart to admit of a considerable opening being made. The character of the material looked exceedingly well, although changing from day to day as the work progressed, not so much, however, as in the case of those deposits so largely associated with clays. Probably 15 or 20 tons of ore were being mined here a day all of which was well prepared and no doubt gave good results in the furnace.

In a letter under date of June 7, 1887, from Messrs. C. W. Ahl's son, proprietors of the Katharine furnace, this ore is said to yield 50.50 per cent. of metallic iron and .154 per cent. of phosphorus. No other analysis of this ore was obtained, and none was secured by Mr. McCreath during his collections in 1881.

South-east of Shippensburg, in Cumberland county, several old banks occur in the lower part of the limestone measures, in the vicinity of Cleversburg.

John Bridges' opening.

This lies about midway between Shippensburg and Cleversburg. No washing was ever done here and the ore-material had only been sparingly dug into, perhaps with a view of learning the character of it or for sending it to some operation in the district for trial. The opening is close to Mr. Bridges' house and about 100 yards north of the public road. The character of the ore is above the average of the various limestone openings of the valley, as evidenced by the following analysis:

Analysis of the Bridges ore.

Metallic iron,	52.950
Metallic manganese,	.266
Sulphur,	.039
Silicious matter,	9.500
Phosphorus,	.131
Phosphorus in 100 parts iron,	.247

J. H. Cressler or Old Clippinger bank.

This lies about 250 yards north of the Fayetteville and Big Pond road, and about two miles south-east of Shippensburg. It is a limestone ore-bank, worked over about two acres, and most of the ore mined here went to the Cleversburg Furnace company, who praise it very highly. The opening had not been worked however for four years prior to the fall of 1886, and consequently there was but little showing to reward the visit paid to it. A handsome outcrop of ore extends north and south along the little valley in which this opening is located; but beyond that fact there is little to be said regarding the character of the ore in the bank itself, for none such could be seen. The following analysis, however, would fairly seem to justify the good opinion of those who mined here:

Analysis of the J. H. Cressler or Old Clippinger ore.

Metallic iron,	48.850
Metallic manganese,	.245
Sulphur,	.027
Silicious matter,	14.780
Phosphorus,	.146
Phosphorus in 100 parts iron,	.298

Chestnut Ore bank.

This is situated further out in the valley on the west side of the road from Cleversburg to Leesburg and about four miles E. N. E. from Shippensburg. It is entirely in the limestone formation, being fully one mile from the mountain. The cut had entirely fallen in, and was filled with water, its dimensions being about 100×60×20 feet. No ore was visible anywhere in the cut, unless some very small pieces of wash-ore be evidence of what may exist beneath the deep covering of wash then visible.

But the character of the ore once mined here was evidently quite good as may be judged from the following analysis:

Analysis of the Chestnut bank ore.

Metallic iron,	40.600
Metallic manganese,	.844
Sulphur,	.023
Silicious matter,	25.350
Phosphorus,	.308
Phosphorus in 100 parts iron,	.758

Muslin bank (George Clever).

This is another limestone opening about a half a mile north along the Big Pond road from the cross roads, and situated between the Chestnut and George H. Clever banks. It lies somewhat nearer the mountain than the Chestnut mine, although a good half mile from its base. Some very good ore has been taken from this cut, but the opening was a small one, and was also well filled with water. This ore was used at the Cleversburg furnace at one time and highly spoken of there, and its outcrop extends for some little distance north and south through adjoining fields. According to Mr. Stewart, of Shippensburg, quite a considerable amount of ore was taken from here and used at Harrisburg furnaces; but the mine was finally abandoned by reason of the expensive haul to the railroad. One curious feature of this ore deposit, but one which may be expected at any time in working these brown-hematite ore mines, resulted from the location of an 80-foot shaft in the center of an otherwise promising ore pit, which, however, only developed a stiff white clay through the entire distance.

Analysis of the Muslin bank ore.

Metallic iron,	44.950
Metallic manganese,	.987
Sulphur,	.025
Silicious matter,	16.860
Phosphorus,	.535
Phosphorus in 100 parts iron,	1.190

Calico bank.

This is situated about three miles N. W of Shippens burg and consists of two openings, the *Rutherford min* and the *Coover mine.* Both practically constitute one ore bank and occupy an area N. E. and S. W. of about 800 feet N. W. and S. E. 200 feet, and worked to varying depths i terraces and isolated pits, but rarely over 20 feet. Ruther ford is the most north-easterly, and is probably slightly th larger.

The ore occurs entirely in limestone clays, some blu limestone however showing in different parts of the bank with an apparent N. W. dip and most conspicuously see at the north end. Work had been actively pursued her up to within a week of inspection; but owing to exceed ingly heavy and continuous rains during the interval, i was well-nigh impossible to say whether the mine was a ore-deposit or a mud bank. At that time most of the or which had been mined went to the Paxton furnaces at Har risburg, and the quality of the ore was quite up to, if no better, than the average results obtained in these limeston deposits. Both banks had been worked in narrow trenche wherever the material seemed to pay best and seemed easies of extraction, so that partially barren knobs showed al through the openings, many of which, in systematic mining could have been with reason put through the washer There was still a considerable area of good territory sur rounding the openings that had been washed remarkabl clean by the rains, and the ore on the dump, some 40 or 5 tons, showed a well prepared brown-hematite, of lemon color and usually in small lump sizes. Most of the recen work done had been confined to the center and south-wes sides, and the occasional presence of some dark, black and gray clays, was quite a noticeable feature of the deposit.

The mine is quite typical of its class, and will no doub be worked in the future, despite its somewhat disadvan tageous position with regard to railroad facilities. Th analyses of the lump and wash-ore from both openings ar appended together below.

Analysis of the Calico bank ore.

	Coover opening	Rutherford opening.
Metallic iron	47.550	50.300
Metallic manganese,	.094	.094
Sulphur,	.046	.041
Silicious matter,	17.720	13.440
Phosphorus,	.086	.086
Phosphorus in 100 parts iron,	.180	.170

In *Franklin county* there are also several banks in the limestone, in addition to those occurring near Quincy and Mont Alto, in such a position as to make their true horizon uncertain.

Ahl bank (Old Johnson mine).

This is situated about one and a half miles W.-S. W. from Shippensburg, and in the latter part of October, 1886, was just being re-opened by the Catharine furnace after an idleness of seventeen years. The old pit shows a somewhat irregular opening, about 100×60×12 feet deep, and when last seen was very much washed-in, although showing a large amount of excellent wash-ore on all sides. A belt of limestone about 20 feet wide runs in an east and west direction through the bank, with red ore-bearing clays on each side of it.*

The outcrop of the ore extends N. W. along the public road for several hundred yards, and is seemingly quite rich and very profuse. The whole property comprises about eight acres, and the old bank was being re-opened by the company for their ore supply. At that time the locality was without railroad connection, although the railroad could be reached in a comparatively short distance. This bank is situated entirely in limestone rocks, which outcrop more or less in the vicinity and in the ore-bank itself; but unless indications fail greatly, there can still be

*A well was being sunk on the S. E. side of the cut for the purpose of obtaining a suitable water supply for washing the ore. It was, October 28th, 40 feet deep through loose limestone rock and clay not ore-bearing.

a large amount of cheap and good ore mined at this point. The character of the material, from an old analysis by Mr. McCreath shows:

Metallic iron,	55.150
Metallic manganese,	.165
Sulphur,	.024
Silicious matter,	7.780
Phosphorus,	.114
Phosphorus in 100 parts iron,	.206

McHose bank (Old Neikirk mine).

This lies about three miles S. S. W. of Shippensburg, a little west of the Cumberland Valley railroad, and on the north side of the road running from the railroad to the pike. This is a large and very irregular open working, extending some 600 feet north and south, and averaging 200 feet east and west and from 10 to 20 feet deep. It is entirely in limestone, which shows in several places in the bank, dipping gently to the S. E. but is not a conspicuous feature of the opening. The wash-ore exposed in various parts of the cut looked exceedingly well, although as the bank had been idle for several years the usual disfigurement of the ore-faces had taken place here as elsewhere in the region. The overburden is usually very light. In many places the ore shows abundantly on the surface and extends northwards for some distance to and across the property line into the Stewart farm, where there is also an abundant outcrop, but up to the time of the inspection no developments. While the McHose bank itself has barren spots in which very little ore is to be seen or expected, the whole character of the opening was very auspicious and the bank could only have been abandoned on account of the low price of the ore or some defect in its character in the limited market it could command.

That much good ore has evidently been mined cannot be doubted, both from the character of the material left behind and from the amount of development evident from the size of the opening. The clay with which the ore is associated is not refractory, so that the ore will no doubt wash well and cheaply. The deepest portion of the cut is toward the

north end which evidently had been most recently worked; but the haul from here to the washer on the road and then with the clean ore from the washer to the railroad no doubt largely increased the expense of mining it. The deposit itself is probably shallow, but at the same time it covers quite a large area of ground. Barren knolls show also at the north end, surrounded by excellent ore and with modern equipment and a fair supply of wash water, this ore should be as cheaply mined as any in the valley. Along the east side of the cut the ore comes practically to the surface; but on the slope of the hill from this side towards the railroad, very little outcrop is to be seen. Probably forty or fifty tons of well-prepared wash-ore still remained at the washer, most of which was taken out during the early summer by some Reading parties. There are abundant indications of an extension of this ore deposit westward which, however, is as yet untouched ground. The mine machinery was fast going to decay, and there was no evidence of the intention on the part of the proprietors to start work again in the immediate future. The character of this ore is shown by the following analysis:

Analysis of the McHose bank ore.

Metallic iron,	44.950
Metallic manganese,	1.203
Sulphur,	.040
Silicious matter,	19.470
Phosphorus,	.138
Phosphorus in 100 parts iron,	.307

Cressler and Koser banks.

These are two openings situated close together on the north flank of the low ridge marking the base of the limestone formation No. II, and the beginning of the calcareous transition slates near the top of No. I. They are about three miles south of Shippensburg and probably three-quarters of a mile east of the McHose bank and near Furnace run. The Cressler opening, the most eastern of the two, shows a pit of great irregularity in which the sides are greatly washed and but little ore of any kind exposed. The

surface here has been hogged over for 400 feet north an south and 200 feet east and west, and in isolated spots ci cular holes dug some 40 feet deep. Barren domes of yel low sandy clay are interspersed between the productiv and non-productive portions of the cut, and the whole char acter of the opening suggests the presence of a very vari able ore deposit, difficult to mine on account of the grea excess of dead clays. The ore material now showing is a best very lean.

The *Koser Bank* to the south-west is, if possible, in an eve more unsatisfactory condition. It nowhere seems to hav been worked to the same depth as the holes in the Cressle bank, and a large portion of the ore material taken fron it was evidently hauled to the Cressler washer.

Both openings make practically one ore-bank, opene continuously along the outcrop for 600 feet and from 10 to 200 feet wide. From the appearance of these banks i October, 1886, most of the cheap ore had certainly been re moved, and under the past system of working, not to th ultimate advantage of future mining, if ever carried on here

A considerable amount of ore was evidently obtained and obtained in the most expeditious and ruinous man ner. Both banks looked very poorly and seemed especiall barren of ore along the N. E. side and best towards the S W. end where there was some good liver-colored hematit still exposed. West across the fence marking the propert line, and close to the present outline of the ore banks there is an abundant outcrop in the adjoining field, an any future ore mined from this locality must be eithe obtained there or further N. E. along the outcrop. Th base of the ridge limits the outcrop and is made up of lime stone dipping about 40° N. W. The variation in the char acter of the ore, mined from practically the same ore bank but upon different levels, is conspicuously shown in th subtended analyses of these two openings, and no bette illustration could be given of the varying nature of thes brown-hematite deposits :

Analysis of Cressler and Koser ores.

	Cressler.	Koser.
Metallic iron,	38.600	47.000
Metallic manganese,	.698	1.260
Sulphur,	.029	.030
Silicious matter,	29.970	15.650
Phosphorus,	.178	.296
Phosphorus in 100 parts iron,	.461	.629

W. L. Chambers' openings.

These lie about one mile west along the road from Scotland to Greenville, and are situated between the Western Maryland and Cumberland Valley railroads though much closer to the latter. The openings are some distance (400 yards) north of the above mentioned public road and in the second field. Some hogging has been done over about half an acre of ground, and the ore obtained from these very irregular pits must have been screened, inasmuch as no washer is to be seen anywhere in the vicinity. The ore deposit has no great depth apparently, and if there is to be any choice, the extreme north end looks best. The shallow excavation is nowhere over six feet deep, and the integrity of the ore deposit is somewhat ruined by the frequent appearance of limestone rocks, which, hereabouts, dip about 30° to the S. E. It is improbable that any considerable body of ore will be found here, owing to this structure, the limestone rock cutting off the ore in many places. The ore itself is a light brown to yellow hematite, which would wash readily and is no doubt of good quality. There is a good showing in the next field south also and close to the line fence on the west. An analysis of 75 pieces taken from the surface ore gave:

Analysis of W. L. Chambers' ore.

Metallic iron,	53.000
Metallic manganese,	.057
Sulphur,	.027
Silicious matter,	8.770
Phosphorus,	.117
Phosphorus in 100 parts iron,	.220

A small nameless pit located on the Cumberland Valley railroad about half a mile north of Scotland Valley station

furnished a little ore. It is about 50×30×10 feet; a smal pocket only in the No. II limestone, and showing ver little ore at present.

Path Valley Ore banks.

Path valley is an anticlinal limestone cove in the north western side of Franklin county, extending for about te miles in a N. E. and S. W. direction along the eastern bas of that portion of the North mountain locally known her under the name of the *Tuscarora mountain.* It ends o the S. W. in a cove between this mountain and an outlyin spur known as *Bear Knob,* while to the N. E. the anticlina lies about midway between the *Round Top* and *Dividin Mountain* spurs. The limestone of No. II is exposed i this valley between Doylesburg on the N. E. and the Rich mond furnace on the S. W. and is nowhere over two mile wide, tapering toward each end. The north dips towar the mountain flank are usually somewhat steeper than thos on the south side of the axis, especially for a distance o six or eight miles in Metal township, owing largely to th presence of a fault along the base of the mountain, whic swallows up a large portion of the No. III slate formation and opposite Fannettville brings the limestones of the val ley within close proximity to the mountain sand rock No IV. Along this line the dips are often vertical, if no overturned to the S. E., and it is mainly in this portion o the limestone area, near the junction of Nos. II and III that the iron ores of this region are exposed and develope for a distance of about eight miles between Richmond fur nace and Fannettville. The South Pennsylvania branc of the Cumberland Valley railroad was originally con structed to reach these deposits, which were then though to be of great extent and purity, but which after a con siderable development, have proved a source of expensiv disappointment to the projectors of the road and those in terested in the resources of that region.

Richmond Bog Ore bank.

This is the first commercial deposit on the S. W., situated a short distance west of the old furnace site and about 3,000 feet north of the Bear Knob spur. The old opening has been long abandoned and shows a shallow pit 20×20×10 feet deep, from which a comparatively small amount of ore was taken, but ore of uniformly good character, being rich in metallic iron and low in phosphorus, as shown by the following analysis:

Analysis of the Richmond Bog ore.

Metallic iron,	40.550
Metallic manganese,	trace
Sulphur,	.370
Silicious matter,	24.530
Phosphorus,	.036
Phosphorus in 100 parts iron,	.088

Mt. Pleasant bank.

This is a much more extensive development and perhaps the largest mine in the region, lying still some 3,000 feet north-east along the base of the Tuscarora mountain, and shows practically two cuts independent of one another, divided by an extensive bank of barren, tough clay on the S. W. but afterwards uniting into one excavation towards Cowan's gap. The eastern opening, and the one farthest from the mountain, is 250×100×60 feet extreme measurement, although these dimensions by no means represent the total ore tonnage gotten here, inasmuch as the bank has largely filled up since its abandonment. All the steep bank on the eastern side of the cut is composed of a red sand wash fully 60 feet high, forming a wall around the ore deposit, but entirely barren of ore itself. Some few decomposed layers of sandstone show through the wash with an apparent steep and overturned (?) dip toward the S. E. beneath which, lower down in the cut, the brown-hematite ore occurs with a somewhat conformable dip. The barren strip of ground which separates this opening from the one closer to the mountain is largely composed of

white, blue and yellow clays, north of which the ore is much more dense and close grained, and occurs beneath a dark sooty black clay. This opening and several others in this district were visited in company with Mr. George Rice, who was the last extensive operator here; and he reports that when work was stopped at this mine, a considerable body of ore was left in this western cut, dipping N. W. toward the mountain in a bed some 10 or 20 feet thick, having a lenticular shape, and cut out in places by barren clays. No portion of this western cut has been worked to as deep a level as the first one described, and in the extension of the excavation northwards to where the two openings unite, the development has been carried down to the general level of the eastern mine. This northern extension was probably 200 feet long, making the total length of the cut some 450 or 500 feet. Water occupied the bottom of this cut some 15 or 20 feet deep, so that it was impossible to substantiate the statement that the barren clay bank had expired at this point and that wash-ore, of more or less good quality and richness, extended completely across the opening.

On the mountain side quite a heavy overburden rendered the further development of the ore bank expensive, being from 8 to 20 feet thick and of course increasing rapidly for every yard the opening was extended towards the hill. Much of this mountain wash has now disintegrated and fallen into the bank, effectually concealing the ore faces and rendering the general appearance of the bank very unattractive. The total yield from the entire cut is said to have approximated 100,000 tons; but when abandoned, not a great deal of cheap or good ore was in sight, taking all things into consideration. Barren domes of white clay occur at various points throughout the mine, and that the character of the ore was of good average purity, is made evident by the following analysis:

Analysis of the Mt. Pleasant bank ore.

Metallic iron,	47.500
Metallic manganese,	2.334
Sulphur,	.052
Silicious matter,	11.670
Phosphorus,	.339
Phosphorus in 100 parts iron,	.713

Beaver bank.

This lies a short half mile still further north along the mountain, and is a roughly oval pit, 150 feet north and south; 200 feet east and west, and from 20 feet deep at the east side to 40 feet deep near the mountain. A good body of ore is likewise said to have been left along the east side of the excavation when work was stopped; occurring in a wide face extending well along the cut, and about 20 feet thick, from which ore of a slightly better quality was mined than that obtained from the Mount Pleasant bank.

A rib of barren iron-stained sandstone extends through the center of this cut and another similar deposit shows on the west side against the mountain, west of which a small drift was driven toward the mountain into a small but good bed of ore, where the prospects were quite favorable. No black clay showed in any part of this opening, the barren material having largely a red color.

The whole output from this opening was about 10,000 tons; the ore occurs in a very irregular manner and in its extraction it was found very expensive. The appearance of the cut now is of course very unfavorable, for no work has been done here for a considerable period of time. It is claimed that a good body of ore still remains; for a well sunk in the centre of the pit, some 80 or 100 feet deep, showed a good amount of wash-ore throughout.

The character of the ore is shown by the following analysis:

Analysis of the Beaver bank ore.

Metallic iron,	42.400
Metallic manganese,	1.441
Sulphur,	.045
Silicious matter,	19.530
Phosphorus,	.282
Phosphorus in 100 parts iron,	.665

McGowan's pit.

This lies about 1,000 feet still further north, but in pr tically the same geological position with reference to t rocks occurring in this valley. The opening is not la and shows evidence of having been very irregularly work probably under a sub-contract to individual miners, w endeavored to obtain their ore-supply cheaply and witho regard to any future demands.

The material mined here was almost entirely wash- and as was the case at the Beaver opening, the black clay conspicuously absent, while the white and yellow clays p dominate rather than the red.

All the ore mined here was raised during the early dev opment of this field, except to a small extent in recent tin when the bank was re-opened for a short time by M Lucas.

Several other additional small pits are located with sight of the larger one, all of them shallow and one twen feet deep, which was reported to have been entirely in and to have been abandoned in a good lump-ore deposit.

All the openings so far described have been located up lands owned by the South Pennsylvania Mining and Ra road Company, who own about 6,000 acres of land in t vicinity in addition to holding perpetual leases at low figu in several thousand acres more. There is no evidence, ho ever, of there being any immediate intention of renewi operations here; indeed negotiations were in progr during the fall for the sale of all merchantable mini machinery and track, looking to a final abandonment of t field on the part of the present owners.

Old Johnson and Lessig banks.

These are two openings well up the mountain flank, lyi to the north of the last described pits and between the and the Carrick furnace property.

The *Johnson bank*, the most southerly of the two, sho one small opening from which probably 500 tons were o tained. The ore occurs mixed through a surface wash

sand and clay, and the ore raised here was hauled to Carrick furnace in the valley, when that plant was in operation.

The *Lessig tract* shows several small openings, the most northerly being a small pit which has yielded about 200 tons, largely of a slatey character and generally cold-short. Some very good porous brown-hematite has been taken from pits sunk to the south 10 and 18 feet deep, which was quite clean and good ; but the amount could not have exceeded 50 tons. This also went to Carrick furnace. The outcrop is fairly continuous, however, through both these tracts, and there is still an amount of cheap ore which could be easily mined, providing it was of desirable quality.

Carrick furnace property.

This joins the Lessig tract on the north and extends for probably one and a half miles along the mountain flank. About 200 yards from the Lessig line, a shallow open cut 50 × 30 × 10 feet is reported to have yielded a good quantity of ore, and a hole 10 feet deep in the bottom was abandoned in ore. The bank shows about 7 feet of stripping and an open, porous, hematite, mainly of the wash-ore variety, which is said to have made an excellent tough iron.

In 200 yards more, there are a couple of ore-openings showing about 50 × 25 × 15 feet deep, the lower one quite barren ; the upper one nearer the mountain still exhibiting some dense ore which, however, was condemned in furnace use. Some 500 tons may have been mined at this point, and its condemnation in the furnace is a very strong proof of the variability in character of these brown-hematite ores; for there can be no question about its occurring at exactly the same geological horizon as that taken from the small pit first mentioned, said to have yielded a first class commercial ore. Moreover the general character of the ore was evidently good, as shown by the two analyses of the wash and lump-ore given below. The sand-wash stripping here is from 4 to 8 feet thick, and the ore is generally a fine wash, with very little lump showing. About 50 yards still

further north (with innumerable pits between) there is qu a large opening 100 × 50 × 30 feet deep; in which a sh 25 feet deep in the bottom produced some excellent lu ore. The outcrop between this opening and the l described is fairly continuous, and the entire product the larger cut is said to have been of good quality, cl and readily mined. All of this ore was used at Carr furnace, whose iron was highly thought of.

No water of any consequence occurred at this bank wh is equally true of all other developments in this region, that the proper preparation of this ore and others wh the ore material itself was at all difficult to cleanse, beca a matter of considerable difficulty, and often led to abandonment of openings.

The stripping is not heavy at this place, but in devel ment the deposit was found to lie like a nest or pock somewhat lenticular in shape, thinning and thickening places, but finally pinching out on all sides at no great d tance.

In one hundred yards along the mountain northwa there is an opening at a slightly lower level, which m have yielded quite a large amount of ore. The cut is × 50 × 20 feet; but most of the ore was found along mountain side of the cut, where a slope 20 feet long carried down on lump-ore of good quality. This was old opening and was worked by General Dunn many ye ago. The ground here has been greatly hogged over, a somewhat ruinously developed. Numerous pits have be sunk west towards the mountain where another openi occurs, quite shallow, but 100 feet long, from which pro bly 150 tons of ore were mined, mostly small lump a wash.

Analysis of the Carrick furnace ore.

Metallic iron,	45.300
Metallic manganese,	1.102
Sulphur,	.048
Silicious matter,	16.280
Phosphorus,	.355
Phosphorus in 100 parts iron,	.783

Old Carrick ore bank.

This is situated probably a half mile north along the mountain, and just in front of a wind gap in the mountain, through which the public road passes into Huntingdon county. At this point the No. III slates are very thin, owing to the presence of the fault before described, and the ore-opening lies close to their junction with the valley limestone. The excavation is about 300 × 40 × 25 feet, and a shaft 125 feet deep from the bottom of the open cut is reported to have passed through a steeply dipping ore-bed, estimated at from 30 to 35 feet thick. At the west end of the cut another shaft has been sunk 75 feet through this ore and stopped in massive lump-ore. Neither of these statements could be verified by personal inspection, as work has been long abandoned here and everything is in the most dilapidated condition.

Most of the ore mined here was taken out through underground workings, which were extended some distance to the north and south of the ravine. In this bank curiously enough all the west side of the open cut towards the mountain shows a soft, sooty black clay, similar to that found capping the ore in so many of the mines along the flank of the South mountain. James Richard opened this bank for Messrs. North & Company when they leased the property. Afterwards Messrs. Springer, Hunter and McHose worked it successively through a period of six or eight years. Mr. Shalter operated after them for four years and finally Messrs. Bland and Spang, who were the last lessees of the Carrick furnace property. Estimates of the ore raised from this open cut vary widely, and in the present condition of the mine, it is impossible to even approximate this tonnage, much less adjust the wide differences reported. The character of the ore furnished to the Carrick furnace property during 1879–80, comprising material mined at various points on the property is shown by the following analyses of samples gathered at the stock pile by Mr. McCreath:

Analysis of the Old Carrick furnace ore.

	Lump ore.	Wash ore.
Metallic iron,	45.300	36.400
Metallic manganese,	1.102	1.758
Sulphur,	.048	.055
Silicious matter,	16.280	26.050
Phosphorus,	.355	.267
Phosphorus in 100 parts iron,	.783	.733

Railroad bank (*Carrick Furnace Co.*).

This lies probably 400 yards further along the hill. Th cut is about 400×40×15 feet deep, and in the fall of 188 there was scarcely any ore exposed in its sides. The strip ping here was very heavy. On the south side of the cut shaft 40 feet deep is said to have been entirely in ore, fron the bottom of which gangways were driven north and soutl for some distance through good material. This method o working was made necessary by the topography of th ground and to avoid the exceedingly heavy washings whicl constantly threatened the open workings. The open cu shows only lean and barren clay domes now, and yet, t judge from the size of the excavation, a very large quantit of ore must have been taken from here. The lump-ore which occurred in the bottom, was generally blasted an was afterwards broken into small pieces before being charge into the furnace. The analysis shows a very large increas of phosphorus.

Anlaysis of the Railroad bank ore.

Metallic iron,	43.600
Metallic manganese,	.238
Sulphur,	.005
Silicious matter,	18.500
Phosphorus,	1.482
Phosphorus in 100 parts iron,	3.399

Very little could be learned concerning a few additiona openings lying still further north on this range and on th north side of the Fannettville road. The outcrop extend with more or less distinctness for probably a mile and wa opened at the George Wineman farm, and in some few pit on the McCallan land nearer the public road. Neither o these localities ever furnished a commercial amount o

ore and the old cuts were hardly visible. The analysis of the surface ore, made from a sample of loose pieces lying around the opening, gave:

Metallic iron,	48.200
Metallic manganese,	1.066
Sulphur,	.070
Silicious matter,	12.940
Phosphorus,	.415
Phosphorus in 100 parts iron,	.861

George Umbrill opening.

This was the last opening visited on this range, lying probably a half a mile north of the Wineman pit and showing ore of a very doubtful quality. Nothing could be learned of the nature of the deposits in this part of the field and the general stagnation of the mining industry has deferred their development for the present.

Leib, Stouffer and McFarland banks.

These are three small openings situated a short distance east of Mercersburg in the order named. None of them furnished any considerable quantity of ore, although their product was of good quality. These mines were not visited personally, as no work had been done in them for several years, so that their exact location and geological horizon cannot be definitely stated; the ore, however, is largely bog-ore occurring in the slates of No. III. The analyses of these three banks show:

Analyses of the Leib, Stouffer and McFarland ores.

	Leib.	*Stouffer.*	*McFarland.*
Metallic iron,	35.200	48.850	35.750
Metallic manganese,	trace.	trace.	trace.
Sulphur,	.349	.297	.355
Silicious matter,	27.840	20.030	26.720
Phosphorus,	.046	.037	.087
Phosphorus in 100 parts iron,	.130	.090	.243

Squire Stinger bank.

This is an old opening developed by several shafts, situated near the junction of the limestones (II) and slates (III) at the mouth of Bear Valley, in Peters township, about

one mile east of Loudon. A small amount of ore was tak from this locality during the active development of t region. Nothing, however, has been done during late yea and there is only the analysis of the ore, given belo to speak for the character of the material mined.

Analysis of the Squire Stinger bank ore.

Metallic iron,	39.500
Metallic manganese,	4.791
Sulphur,	.042
Silicious matter,	18.810
Phosphorus,	.606
Phosphorus in 100 parts iron,	1.534

The various shallow openings are scattered over an a of about 400×400 feet and are all fallen shut.

The ore seems to have occurred close to the junction Nos. II and III, as in Path Valley.

The product mined here was used in the small furnace the immediate vicinity.

Garlic bank.

This is a similar opening lying further east and abo 2½ miles south-west of St. Thomas, in Hamilton townsh This mine shows an open cut 200×100×20 feet. The si show red clay carrying a fine ore and some little lump.

This mine has not been worked for probably 15 years, that it is impossible to state the character of the mater still remaining or the amount of it.

If more favorably situated relative to a railroad, the go quality of its ore as shown by the analysis below, from sample collected in 1881, should warrant its re-opening.

Analysis of the Garlic bank ore.

Metallic iron,	52.912
Metallic manganese,	.079
Sulphur,	.150
Silicious matter,	6.890
Phosphorus,	.056
Phosphorus in 100 parts iron,	.105

Webster opening.

This is a small operation situated two miles west-north-west of Mercersburg, and near the Peters and Montgomery township line. It occupies a similar geological position to the Garlic and Path valley ore mines.

It was also idle, and the character of the ore is as follows:

Analysis of the Webster bank ore.

Metallic iron,	44.700
Metallic manganese,	.202
Sulphur,	.054
Silicious matter,	17.250
Phosphorus,	.636
Phosphorus in 100 parts iron,	1.422

Bowers Furnace bank.

This is on Mrs. Eliza Furray's farm, 9 miles south-west of Mercersburg, in Warren township. It should be mentioned to complete the list of old operations in this part of the county. The ore mined here came from the No. VIII *Devonian slates*, a much higher geological horizon than any hitherto discussed in this report.

The ore mined was used at the old furnace near by.

There are openings for 1000 feet in length and 300 feet in breadth; but they are very shallow. The ore occurred in large and small lumps, much of it regularly bedded between walls of slate; elsewhere mixed with clay and sand. All the openings are largely concealed at present. The following is an analysis of the ore from a sample taken in 1881:

Metallic iron,	47.000
Metallic manganese,	.410
Sulphur,	.116
Silicious matter,	17.280
Phosphorus,	.085
Phosphorus in 100 parts iron,	.180

The Dillsburg ore mines.

In the neighborhood of Dillsburg, York county, there are a number of mines from which a considerable amount of magnetic iron-ore has been taken. Some few mines are

still in active operation and are supplying ore daily to th Harrisburg and Susquehanna furnaces, as well as to th general trade. These openings are situated within a radiu of about two miles from Dillsburg, and in the Mesozoi (New Red) sandstone formation, and present many feature peculiar to themselves. This region has received more o less attention in the past from various members of the sur vey, and was reported upon at considerable length by Dr Persifor Frazer, in report C, in 1875. Many details con cerning the points visited will be found in that report; th only object of the present examination being to bring th data bearing upon this interesting series of ore-bearin rocks up to date, and for that purpose only the active mine in the district, lying generally from one to two miles eas of Dillsburg, were visited. None of them can be called ex tensive mines and they are worked in a rather perfunctor manner, as the demand for their product arises; but inasmuc as they all yield an ore suitable for Bessemer purposes their product receives more or less constant attention fron the iron masters in the vicinity, and there is generally a active enough demand from that source to warrant the ex penditure of time and money in developing the mines t some extent. The description of the active workings wil be taken up from the east westward, none of the mines t the south-west of the village having been visited.

The developments so far made seem to show a great uni formity in the manner of occurrence of the ore-beds, whic everywhere shows a lenticular shape to the deposit, some times quite extensive, but usually pinching out within ver narrow limits, owing to the very gradual convergence of th foot and hanging walls.

This structural feature of the ore bodies is quite pro nounced throughout the Dillsburg district, and while, per haps, it would be injudicious to formulate any theory as t the structure of the field and the causes which have influ enced it, nevertheless it seems fairly well maintained by th history of development here, that there are several beds o ore, practically overlying one another geologically; al dipping gently towards the north, and each individual be

feathering out to nothing at a point vertically beneath where the next one geologically higher outcrops. In this way a cross section line drawn in a north and south direction will pass over the successive beds, the lowest one *geologically*, outcropping furthest south, and only traceable beneath the ground to a distance corresponding to the position of the outcrop of the next higher one in the series. Whether this duplication has been caused by faults of small vertical extent, or whether the ore beds are essentially different, it is impossible at this stage of our knowledge of the New Red sandstone formation to state with any degree of certainty. If the beds were of a considerable extent longitudinally, or if they occurred with special well recognized foot and hanging walls, it might be possible to construct such a section as to prove either one or the other of these theories; but in any one mine, the eastern and western extension of the ore, as well as its continuation along the line of dip, is a very uncertain factor; and at best, is too insignificant to warrant looking upon these deposits as being anything else but lenticular-shaped masses, occurring without seeming regularity as to thickness or extent, and each one having to be developed separately upon its own merits. The most marked feature possibly, is the uniform north dip of the whole series, which is sufficient to suggest its close relationship to the rocks with which it is found and with whose dip it is conformable.

The presence of a bastard limestone is asserted in many portions of the field, and certainly the gangue rock is largely composed of the silicates of lime and magnesia, which are such characteristic constituents of the Cornwall and Boyertown deposits further east. The analyses of the ores in the Dillsburg district are not unlike those of the large mines in Lebanon and Berks counties, and there is everything except their geological horizon to strongly associate them in character with those larger deposits. They are, however, situated—at least most of them—at some distance from the margin of the Cambro-Silurian limestone of the valley, and within the body of the New Red sandstone; and in this particular they present a marked difference

when compared with the Cornwall and Boyertown ores. Trap rock occurs near the ore in the Dillsburg mines just as it does in Lebanon and Berks counties; but it would not seem advisable, after a study of those larger developments, to suggest that this relationship has anything to do with the *occurrence* of the ore, although it might have had considerable effect upon its present character. In both cases the ore is in some manner associated with calcareous slates in which the original ferruginous material no doubt occurred; and there is no good reason to deny the possibility of the occurrence of such ore-bearing material in limestone and slate areas within the New Red sandstone formation, as well as in the older Palæozoic rocks, although the manifestation of limestone within the New Red formation in Pennsylvania is still quite rare.

Cox mine.

This is situated on the Price farm, from which it is leased on the basis of a ten per cent. royalty of the selling price of ore at Dillsburg. The present operation is situated about two miles nearly due east from Dillsburg. The engine house is close to and north of the public road, and the ore-bed is mined by means of a slope some 300 feet long, put down upon a bed of magnetic ore, dipping about 25° a little west of north. An old abandoned slope starts very near the same point descending nearly due north for 280 feet, and a shaft 125 feet north of the engine-house struck the ore-bed near this slope at about 40 feet beneath the surface. All the eastern portion of the mine is now worked out and abandoned, except a few pillars which have not yet been robbed; and the surface here is badly cracked and fallen in. The ore so far developed seems to lie in a deposit shaped like a shell, the top and bottom of the shell coming together and pinching out the ore on all sides along the strike as well as along the dip.

The average thickness of the bed developed in the Cox mine is from 5½ to 6 feet, though in places it swells out to 9 feet. Generally the ore-bed has a gray dolorite trap for a hanging wall and a sandy bastard limestone for a foot.

wall; but there seems to be no very persistent character for either. The whole western side of the deposit seems more mixed in character than the east and in places the trap wall seems to stand almost vertical, squeezing the ore into a narrow compass, and in time coming immediately against the foot wall. This foot wall, in a majority of the places seen in the mine, appeared more like a baked white slate rock than limestone, in which some little calcareous matter occurred. The mine is greatly troubled with water and requires continual pumping. In April, 1887, there were ten or twelve miners employed, in addition to five or six other hands attending the boilers and acting as hoisters, landers, etc., and a superintendent. The average product at that time was about 30 cars per day, netting about 25 tons. The ore is all wagoned to Dillsburg by teams, carrying from 4½ to 5 tons a trip, and delivering the ore there at 40 cents per ton.

West of the present slope a small open cut has been made in a rather more sandy ore, from which possibly a couple of hundred tons have been taken. The old open cut on the Price farm is reported to have been fully 350 feet east and west and 125 feet broad in its widest part, and from 15 to 20 feet deep. Hardly any sign of this immense excavation can be seen at present, as no work has been done there for probably twenty years.

Mr. Cox has started a slope not far from the creek from which 200 tons, more or less, of good ore were mined from a bed about 6 feet thick, apparently capped with an indurated gray sandy-slate, certainly not a trap rock. Sandstone forms the foot-wall, and the opening was temporarily abandoned during the progress of work in the slope. The general character of this ore is very good, although apt to vary from time to time, especially near the point of contact between the foot and hanging walls.

Bell's mine (abandoned).

This lies between the Cox opening and the Altlandshaft, probably a half a mile N. W. of the former. This opening was last leased by McCormick and Company of Harrisburg,

and a map of the workings made in September, 1884, pri to abandonment, showed a slope some 800 feet long on gentle north dip, in which the ore-body had been work from 5 to 12 feet thick. The dip was about N. 10° E. 2 and hard limestone boulders are said to have occurred in old shaft 33 feet deep from the surface down to the o No detailed information could be obtained in regard to t working; but the general method of occurrence is mai tained at this mine, and the ore-body was worked in a p cisely similar manner, leaving large pillars of ore along t main slope and working the ore-body east and west until wedged out to a mere streak. The bed at this mine w considerably thicker toward the bottom of the slope th where it was first entered; but no very great lateral exte sion of the ore was found to occur here, further than a wid of perhaps 60 feet. The character of the ore which th mine furnished is shown by the following old analysis :

Analysis of the Bell mine ore.

Metallic iron,	42.550
Metallic manganese,	.108
Sulphur,	1.750
Silica,	19.640
Phosphorus,	.019
Phosphorus in 100 parts iron,	.044

Altland mine.

This lies to the N. W. of the Bell mine, and is opened by shaft 62 feet deep from the bottom of which a slope exten northwardly on the ore-bed. This bed must evidently geologically higher than the one worked at Bells, for i outcrop is seen a short distance south of the shaft and w once worked there. The shaft passed through ore first about 57 feet, and the slope is driven north on a 23° dip f about 125 feet, the ore bed varying from 4 to 7 feet thic All along the slope the hanging wall seems to be an excee ingly fine-grained trap, sometimes carrying small crysta of iron pyrites and occasionally nodules of lime. But the present drifts at the bottom of the slope, for 25 feet

each side, an indurated slate rock wedges in between the trap and the ore, and forms a hanging-wall. The ore being mined at present is excellent; but it seems to lie in a lenticular-shaped body just as at Cox's, thickest along the slope and thinning rapidly on the west side. At the same time the ore body contracts rapidly towards the east also, so that the developments have been confined to a narrow area along the line of the main slope. This feature of structure does not apply so much to the bottom of the slope, where the bed holds its thickness well, owing possibly to some difference in the roof rock. The mine is equipped to handle 40 or 50 tons a day. The analysis of this ore which is quite micaceous, shows the following results:

Analysis of Altland mine ore (D. McCreath).

Metallic iron,	57.825
Metallic copper,	.177
Metallic manganese,	.029
Sulphur,	.060
Insoluble residue,	9.530
Phosphorus,	trace

The next developments toward the N. W. are all situated in the vicinity of Mumper's woods, on the crest of a broad, flat hill, overlooking the town of Dillsburg and within a half a mile of it.

Old Smyser opening.

This is situated near the head of a small ravine toward the south base of the hill; but is not now worked and there was nothing to be seen there.

Underwood opening (Old Mumper).

This was opened thirty-five or forty years ago, and lies about 300 yards north from the Altland shaft. The old open cut to the south of the engine house is now abandoned, having furnished several thousand tons of excellent ore from the somewhat irregular cut about 25 feet deep. A later operation developed the same ore bed by means of a slope through the overlying measures on to the ore-bed, which

was carried down some 500 feet before it was abandoned f the present shaft. This old slope is now used for pumpi water from the shaft workings and its gangways are co nected with those of the shaft.

This shaft was about 96 feet deep in April, 1887, and said to have passed through three ore beds; the fi at 38 feet which was 7 to 8 feet thick and rather lean; th 14 feet of sandstone; 8 feet of good ore; 26 feet of sar stone, to the bottom bed 15 or 20 feet thick. The workin are very extensive but are confined entirely to that porti of the territory east of the main slope. The real foot a hanging-walls are respectively a hard white calcarec sandstone and trap-rock, as in the other mines; b between these two walls, lenticular-shaped masses of san stone and slate wedge into the ore-body, and it is no dou due to their swelling that the three beds of ore were fou in the shaft. The old slope was carried down with the tr hanging-wall on top; but in a comparatively short distan the ore-bed forked into an upper and lower seam, betwe which a wedge of slaty sandstone occurred. Both be were sloped upon, and at first were separated with only few inches of sandstone; but upon development beca two distinct beds. The gangways driven to the west of t slope all showed the ore being rapidly cut out by the co vergence of foot and hanging-walls, and the drifts w continually kept turning to the N. E. in order to keep wi in the ore-body.

Peculiarly enough, the best ore in this mine is said have been found near where the bed pinched; and where t bed is thickest the ore becomes more or less mixed w slaty limestone layers, and carries more sulphur in the fo of iron pyrites.

The middle bed of the three has been somewhat larg developed in the shaft. It is not normally very thick, b is of good quality and is said to be entirely encased betwe an altered sand rock roof and floor.

The lowest bed struck in the shaft shows in places a gr thickness, immense chambers having been opened out in where the bed has temporarily swelled; but the increas

size of the bed (15 to 20 feet) is usually at the expense of the general quality; the ore-mass showing seams of limestone and sometimes large boulders of barren rock, around which the purer ore-mass is followed in a manner precisely similar to the development of the magnetic-ores in the Boyertown district. In many places the old gangways of the slope workings have been extended over chambers in this lower bed, so that there is no question of the occurrence of distinct beds in this mine. It is however probable that the two upper ore-bodies as developed in the shaft, are of no great extent, being simply splits from the main bed. They have however furnished a considerable quantity of ore in the past. All this ore of course requires blasting, and while some of it is exceedingly rich, its average will not go far above the analysis given below. The output could be increased considerably, although not now reaching over 50 or 60 tons a day. All this ore is hauled to Dillsburg by teams and re-shipped from there. The mine may possibly have furnished 20,000 or 25,000 tons, the analysis of which is as follows:

Analysis of Underwood or Mumper ore.

Metallic iron,	40.200
Metallic manganese,	.072
Sulphur,	1.931
Silica,	19.030
Phosphorus,	.030
Phosphorus in 100 parts iron,	.074

Longnecker mine.

This lies a little east of the Underwood and is developed by a shaft, reported 95 feet deep and the last 20 feet through ore. The slope extending from the bottom of the shaft has now reached the McCormick and Company line on the north and is probably 400 or 450 feet long. From the bottom of the slope a gangway has been driven 150 feet westward towards the Underwood operation. To the east four more gangways have been driven towards the Logan line. From the west gangway, at a distance of about 50 feet from the main slope, a stope has been driven up some 50 feet and in

some places shows the ore bed to be from 20 to 30 f thick. No new features are presented in this locality o those described in Underwood's mine, and it may be c sidered a virtual extension 400 feet to the east of the sa ore-body, even though the two mines may, as their wo ings are extended towards one another, find the two o lenses tending to overlap each other.

Two analyses of samples from (1) the old mine (2) the n mine, were selected from ore piles at the mine and yield follows:

Analyses of Longnecker mine ore.

	(1)	(2)
Metallic iron,	38.350	43.000
Metallic manganese,	.079	.079
Sulphur,	.650	.015
Silica,	21.830	18.770
Phosphorus,	.016	.029
Phosphorus in 100 parts iron,	.041	.067

Logan mine.

This lies a short distance further N. E. on adjoining pro erty. This operation was idle and no new informati could be obtained regarding it. The direction of the slo at the bottom of the shaft was due north on a dip of 2 and the ore mined is considered to be of the same avera character as the two operations last described. The ave age thickness of the ore bed is stated to be about 10 fe carrying a roof and foot wall of compact hard sandston This mine was last leased by McCormick & Co., of Harri burg, who raised a considerable amount of ore prior to i abandonment in 1885. The main shaft near the Smys property line was 51 feet deep, and the slope extended nor from there 215 feet. For a large part of that distance a immense chamber of ore was worked out from both sides the slope, nearly 300 feet east and west and 160 feet nor and south. Large pillars of ore still protect the slope an smaller ones remain intact in the S. W. corner of this ope ing towards the Underwood line.

From the bottom of the slope an irregular-curving gan

way was driven north-east for 250 feet, ending in a good breast of ore at about 120 feet beneath the surface. Most of this information was obtained from a map constructed for McCormick & Co. before the mine was allowed to fill up with water, a copy of which, together with the Bell Mine workings, will be found in the Annual Report of 1885.

A sample of about 50 pounds of this ore taken by Dr. Frazer yielded :

Analysis of Logan mine ore.

Metallic iron,	45.880
Metallic manganese,	.144
Sulphur,	2.680
Silica,	15.120
Phosphorus,	.023
Phosphorus in 100 parts iron,	.050

McCormick old opening.

This lies to the north-west of the Logan shaft and probably 500 feet north-east of the Underwood mine. There are several open cuts in this area, the most extensive of which lies close to the Underwood line, and worked a bed overlying that developed there. This open cut is a couple of hundred feet long and was opened by John Mumper, forty years ago. On the north side of this open cut a slope was carried down northwards on the ore-bed for some distance; but the bed was found to pinch in that direction and the opening was finally abandoned. Moreover, a bore-hole failed to show any signs of the presence of the Longnecker ore, though continued beyond its natural place; and, moreover, in spite of the fact that this bed is known to exist close to the line fence between the properties not 100′ south of the bore-hole. Consequently this lower bed must be cut out very near the property line, or else it is faulted.

Several smaller open cuts show a short distance north of the large one which worked a higher and thinner bed on the outcrop at a point vertically above where the lower one ceased to be profitable. Still further north bore-holes were put down to test the presence of available ore bodies, but

mainly with a view to prove the extension of any one b which had been formerly actively developed on its outcro The records of these bore holes are given in Report and while they penetrated several thin ore beds at irregu intervals, they were considered as having proved the co rectness of the statement already frequently made, vi that there was no considerable horizontal extent to any o ore bed, and that in process of development on the dip t bed soon became wedged and cut out by the meeting of t foot and hanging walls. Mr. McCormick was probably t first person to demonstrate this structure conclusively means of bore-holes, although it had been perhaps fai well maintained in the history of the region prior to developments.

A second large open cut shows about 500 feet still furth N. W., and is some 300 feet long. This is the most nor erly opening in this immediate district and consideral ore tonnage was won here. A dolerite trap rock seems constitute the hanging wall, dipping slightly west of no about 30°. Two slopes were driven on the ore-bed fr different parts of this long cut, both of which demonstrat the exceedingly irregular nature of the deposit. It is n considered entirely exhausted and work has been aba doned here for some time. The whole surface of the h hereabouts is covered with innumerable small holes, ma of which have furnished a considerable amout of ore; b most of them were exceedingly small pockets, yielding to 100 tons of ore before the bed became pinched by t wall rocks so characteristic of the larger deposits. T character of the McCormick & Co. ore here is shown by t following analysis:

Analysis of the McCormick (Mumper's) mine ore.

Metallic iron,	38.100
Metallic manganese,	.100
Sulphur,	.007
Silica,	22.900
Phosphorus,	.024
Phosphorus in 100 parts iron,	.063

McClure bank (King & Jauss); Joseph L. Grove.

These are two additional mines which should be incorporated in the openings in this district; but they were both inactive, and no information could be obtained above what has been already stated in Report C.

Analysis of the McClure or King bank ore.

Metallic iron,	45.000
Metallic manganese,	.028
Sulphur,	1.297
Silica,	20.330
Phosphorus,	.047
Phosphorus in 100 parts iron,	.104

Old Fuller or Landis mine.

This mine now owned and worked by Mr. Shelley, was the last opening visited in this region, all the others having been abandoned. This mine is situated on Yellow Breeches creek, about 3½ miles south of Mechanicsburg, and close to the Harrisburg and Potomac railroad, which has been extended this far down from Dillsburg Junction. The opening is a short distance above the grist mill on the south side of the railroad and creek. It was not possible to personally enter the mine, and Mr. Shelley states that a shaft 80 feet deep passed largely through trap rock to a chimney-shaped bed of ore, dipping N. N. E., which has also been struck 100 feet east in a shaft only 40 feet deep and dips towards the creek. The ore after selection is very good, some rather lean ore being sorted for different grades of shipments. According to Mr. Shelley there are four or five beds here, separated by short intervals of hard rock, largely of a white color and not unlike a baked slaty sandstone. Preparations were being made in April, 1887, to sink upon the outcrop of a lower bed showing about 100 yards south of the shaft.

Immediately across a narrow ravine to the east of this opening a large amount of ore was formerly raised by Mr. Fuller, and the operation there was supposed to have been

stopped owing to the occurrence of "Potomac marble," whi cut out the ore for a considerable extent through the mi and along the railroad. This rock shows largely throu the field and along the track, where an old abandoned op cut 150×60×25 feet deep developed a large body of soft su face ore, resulting from the decomposition of the bed so 5 to 8 feet thick, cropping in the bottom of the cut, a trending beneath the track and towards the creek. T opening is close to the junction of the No. II limestone the north side of the creek. There are 13 acres in t property through which Mr. Shelley declares that no pinc ing occurs in the ore beds as far as developed.

Two analyses of this ore are given in M[2], from sampl selected by Dr. Frazer in separate levels, and evidently fr the opening on the creek. They are as follows:

Analyses of Landis or Fuller mine ore.

	Lower level.	*Upper leve*
Metallic iron,	44.900	48.350
Metallic manganese,	.272	.122
Sulphur,	.244	.007
Silica,	17.860	16.640
Phosphorus,	.023	.018
Phosphorus in 100 parts iron,	.051	.037

MINES EAST OF THE SUSQUEHANNA.

Hummelstown Ore Mines.

The Hummelstown ore developments are situated from two to three miles E. S. E. of the town of that name in Dauphin county and along the margin of the New Red sandstone formation. Hardly a sign of these old workings is to be seen at present, although they were extensively worked at one time. All the ore mined there was brown-hematite, occurring geologically near the top of the limestone formation No. II in the transition shales occurring between that series of rocks and the No. III Hudson river slates. In this respect they are quite similar to the great Cornwall deposit further east, although that ore is magnetic and the Hummelstown ore is all brown-hematite. But both occur at the southern edge of the Great Valley limestone, near the margin of the Mesozoic formation, the essential difference between the two deposits being the absence of any trap rock at Hummelstown, which perhaps has been an important factor in altering the Cornwall deposit to its present magnetic state.

The north edge of the Mesozoic formation apparently extends much farther out into the valley here than it really does, owing to the disintegration of the red hills and the subsequent washing out of their sides into the valley plain; consequently the ore openings are apparently within the red rock area, although a little uncovering of the soil soon exposes the underlying calcareous clays and slates of the lower rocks in which the ore occurs.

These rocks dip towards the south-east; the New Red rocks towards the north-west. But this non-conformability of the strata is not due to a fault there any more than in the case of the existence of similar structural features at Corn-

wall, Reading, Boyertown and along this whole range the north-east, where the valley limestone and the ore deposits have been proved in some cases to extend beneath the margin of the later formation.

Although there is considerable difference of opinion* in regard to the true structure of this belt of country, the location of the supposed fault has not yet been determined, and the development at Boyertown at least would seem to confirm the truth of the theory of the *non-faulted* condition of this belt. There is very little additional testimony to be obtained at Hummelstown, owing to the entire abandonment of this field and the filling up of the old ore banks; but for several miles east and west the margin of the New Red rocks describes an exceedingly irregular wavy outcrop totally adverse to the usual influence of faults, and for the present at least it does not seem well advised to adopt the theory of a fault finally.

This subject will no doubt receive careful attention from the survey during 1887–88, and in advance of the results of this examination the discussion of this structure can be justifiably postponed.

The question, however, has an important bearing upon the economical resources of this belt of country and will merit the careful investigation it is proposed to give it.

Several thousand tons of ball lump-ore and fine wash-ore were taken from the Franz, Missimer, Blowse and Hershey pits when in actual operation, occurring through clays in beds 4 to 16 feet thick. Some slight amount of outcrop exists through this farm still, mixed with a red sand wash, although the large size surface ore has long since been removed. It was even difficult to locate these several small openings, and they have accordingly been placed upon the map under the name of the "Hummelstown Ore Mines."

Snavely's hill shows some light ore, mixed through slate, but not very attractive in character.

All these openings are at least two miles from railroad outlet, and there is no evidence of an intention to renew operations under these circumstances.

*Annual Report of 1885, Cornwall Mine.

Cornwall mines.

These were visited in April, 1887, for the purpose of inspecting any new developments that have been made subsequent to the extensive report of them incorporated in the Annual Report of 1885. These great mines still continue to furnish an exceedingly large amount of ore to the numerous proprietary furnaces in and around Lebanon as well as to the general outside trade through the valley.

In 1886 the total amount mined here reached very nearly 700,000 tons, and during the month of March, 1887, 68,000 tons were mined, at which rate the total yield for this year would approximate 825,000 tons.

The deep cut in the Middle hill has been extended considerably towards the west and was then perhaps 400 feet long from the opening and displayed a most attractive face of magnetic ore 40 feet high. Nearly all the ore has been removed from the upper levels, especially along the south side, except where the deposit was rather lean and showed a considerable amount of limestone. The recent cuttings on this level have served to expose an excellent series of S. W. dips of both ore and limestone interbedded, and clearly show the whole deposit inclining in that direction and becoming gradually flatter towards the railroad cutting between Middle and Grassy hills. In the middle of the mixed ore and limestone ridge, lying on the north side of the Middle hill deposit, and on the upper level, a three-foot bed of very pure blue-gray crystalline limestone was seen occurring just at the base of the knob nearly on the level of the mine railroad track, lying between and dipping conformably with beds of good magnetic ore. Most of the soft ore has been removed from the north side of this level, and there remains a comparatively small amount of work yet to be done to clean up this entire terrace. The workings have also been extended a little further towards the New Red sandstone country, until the stripping became too severe to warrant further development in that direction.

Big hill has been entirely cleared along the top level and operations have begun upon the second level. The general

ore-face of this mine is still quite as attractive and impres sive as it was during 1885–86, but no specially new featur were noticed beyond the daily variation which any mine i apt to display. Grassy hill has not yet been touche awaiting developments to be carried forward from the low levels of the Middle hill deposit.

Nothing further has been learned concerning the succe or failure of the bore-holes put down upon the Grubb pro erty to the south of the Cornwall mines and somewh higher in the ridges, although it is commonly reported th the results of the borings were not very satisfactory.

Limestone quarries west of the Susquehanna.

105. McCormick & Co. quarry.

At Harrisburg, on the Cumberland county side of the Susquehanna river, there is a continuous exposure of limestone for about 2 miles in width, between Bridgeport and New Cumberland, flanked on both sides by the slates of No. III. Although every exposure of limestone between these two places shows a *south-east dip*, there can be but little doubt that this apparent monoclinal structure is really an *overturned anticlinal*, the plane of the axis sloping towards the south-east and passing east and west near the center of the limestone belt. The McCormick & Co. (old Walton) quarry is situated about half a mile south of the northern area of slate and the railroad, and shows a very extensive cut. The dip is about 25° to 30° south-east here, and the total thickness of the exposure may reach 200 feet. The beds, however, going to make up this combined section are not thick, although beds of far greater width are found here than any usually exposed along the Lebanon Valley railroad.

This quarry has been described in such detail in Report MM, a section of all the beds measured with such care and exhaustive analyses made of them, that it does not seem possible to say anything further about the opening. Some of these beds are nearly pure carbonate of lime, while others contain large percentages of carbonate of magnesia, there being no regularity apparently in the distribution of these two substances through the exposure. The beds vary from 2 inches to over 12 feet in thickness; but few are below 1 foot in thickness.

106. Boiling Springs quarry.

This is entirely worked for supply of flux to the Katharine furnace at Boiling Springs station on the Harrisburg

& Potomac railroad. The quarry is opened along the pi just back of the hotel and exhibits a fine face of bl gray limestone, with a smooth texture, and occurring plates from six inches to a foot and a-half thick. It quite regularly bedded, and while portions of it show usual variations germane to all limestone exposures, ye very large proportion of the 60-foot face here exposed f nishes stone suitable for blast-furnace flux. The dip apparently nearly due east and varies from 20 to 30 degre

106 (a). Between Carlisle and Mt. Holly.

Along the line of the Gettysburg and Harrisburg railro there are several small quarries which have been more less actively worked for furnishing burnt lime to the far ers in the Mesozoic red shale country of York and Ada counties. None of these quarries can be considered of co mercial importance, the total volume of the business do by them being quite small, owing to competition from ot regions, possibly more advantageously situated with ref ence to the source of demand. The character of the sto quarried here was uniformly good for the purposes which it was intended, although in the absence of a chemical analyses, it is not possible to state whether any the limestone in this part of the valley could be profita utilized in the blast-furnace. The Woods quarry, situat about midway between these two points, is probably t largest and most important.

107. William's quarry.

This is opened along the west face of the low hill j north of the Dillsburg branch of the Cumberland Vall railroad, and about 300 yards west of the junction of t Harrisburg and Potomac railroad. About 200 bushels stone are quarried and burned here daily in each go working day of the year; but it only finds its local co sumption among the farmers of the district and is used them for the usual purposes of fertilizers. The quar shows a face about 30 feet high, with blue limestone 20 fe thick at the bottom, overlaid by a few layers of gray sto

turning white, and the whole capped with beds of grayish-white limestone 20 feet thick, which are not considered so pure as those lower in the quarry. They, however, make a good strong lime, and are largely consumed by the smaller farmers of the district. None of the beds are very thick, although the whole makes a handsome exposure, dipping S. E. from 12° to 15°.

108. *Pine Grove quarry.*

This lies on the south side of Mountain creek, just opposite Pine Grove. The deposit of limestone has been tested for about one mile N. E. and S. W. from the old Pine Grove bank up to the Red bank; but the development is entirely confined to the one large quarry. The entire product averages about 2,500 tons a year, and is all used for fluxing purposes at the Pine Grove furnace. The dip of the limestone is S. E. at angles of from 25° to 30° and the thickness of the exposure is not far short of 100 feet. The color of the stone is mostly blue and it is quite massive and comparatively low in silica. The quarry is about 250 × 75 feet, but the main work is carried on at a depth of about 50 feet beneath the surface. Mr. King states that while this limestone contains only about 4 per cent. of carbonate of magnesia and 5 per cent. of silica, the dolomitic limestone in the ore bank near by contains but one per cent. of silica and fully 40 per cent. of magnesia. He also notes the fact that the "fat" valley limestone shows 12 per cent. of silica; but in sulphur he finds the valley limestone to contain only .005 per cent. as against .125 per cent. at Pine Grove. In other words limestones having a higher percentage of sulphur seem to have a less percentage of silica, and while it is not possible to state how far these facts may hold out through a large territory they have no doubt been quite thoroughly tested by the Pine Grove furnace management, inasmuch as the car wheel iron largely produced there requires a minimum of sulphur, and hence the difficulty of using the Pine Grove limestone with the greatest satisfaction. The quarry is rather awkwardly opened for cheap and rapid development, but the somewhat

limited amount of stone required has no doubt led to th adoption of prevailing methods.

109. Williamson quarry.

This quarry, owned by Mr. Hawbecker, is situated clo to the line of the South Pennsylvania branch of the Cun berland Valley railroad, about two miles west from th main line above Marion, and close to the east branch of th Conococheague creek. Geologically, the opening lies ne the top of the limestone formation, inasmuch as the slat of No. III are seen outcropping to the west of the quarr and to the north-east coincident with the line of the creel All the limestone exposed, however, dips to the S. E. *awa* from the slates, at an angle of about 45°, although its di may be overturned. Formerly this stone was largel shipped to Richmond furnace and to other points along th railroad to Harrisburg; but the quarry is now inactive, n doubt largely due to the abandonment of all operations the Path Valley district. The exposure is a large an handsome one and many individual beds in a section poss bly 75 to 100 feet thick, show an attractive limestone, whic should carry a sufficiently low percentage of siliceous ma ter to warrant its use in a blast furnace. Badly situated it is with reference to the present active plants, there is n demand for this stone at present.

110, 110a. Mt. Alto quarries.

A good limestone quarry is situated between this ban and the railroad about three-quarters of a mile from th furnace. The dip is S. E. and probably 60 feet of a face exposed. The limestone is rather magnesian, but of goc quality, and is from time to time used at Mont Alto fu nace, together with the limestone from the Harshma quarry at Quincy. The analysis of this latter stone fu nished by Mr. J. A. Jardine of Mont Alto yields:—

Carbonate of lime,	95.482
Carbonate of magnesia,	2.262
Oxide of iron and alumina,	.440
Silica,	2.340

LIMESTONE QUARRIES EAST OF HARRISBURG,

Dauphin county.

In the examination of the territory between the Susquehanna and Schuylkill rivers, almost every quarry within easy access of the Philadelphia and Reading railroad through the Lebanon valley was visited, although but very few of them can be called quarries of commercial size. The large developments in the neighborhood of Annville and Swatara furnish a very large percentage of the total limestone quarried in this valley, nearly all of the furnace stone used for fluxing purposes coming from the neighborhood of these two places and supplying the different furnace plants at Reading, Lebanon and Harrisburg. Quite a number of the quarries to be immediately described are small, and only worked for local use and for purposes of fertilizing the soil of the farms in the immediate vicinity of the quarry. Many of these are only worked during certain portions of the year, generally during the fall or spring, and the amount, of stone quarried and burned makes up a comparatively small portion of the total tonnage quarried in the Lebanon Valley. The description of the quarries will be taken up in regular order from Harrisburg east to Reading, and the numbers refer to localities marked on the map, each quarry being given a separate number.

1. Wister Bros.' quarry.

This opening lies about 1¾ miles east of Harrisburg, very close to and on the south side of the Reading railroad. The siding extends from the main track close to the working face of the quarry. The latter shows an exposure 25 to 30 feet thick, with an average depth of stripping of about 8 feet. The beds of limestone vary somewhat in thickness from 6 inches to 3½ feet. A large portion of the rock exposed is massive, but full of cleavage. The dips at

both the east and west ends of the quarry are about S.
E. 42° to 52°. The limestone exposed in this quarry
pears to be of a good quality and certainly should be e
nomically quarried; but the quarry is now temporar
abandoned, the stone being a little too high in silica
the purposes of furnace flux. The output all went to
Dunbar furnace.

2. Henry McCormick's quarry.

This opening lies about two miles east of Harrisburg a
on the south side of the railroad, the general trend of
opening being N. E. and S. W. The mouth of the qua
begins at the railroad and extends in a S. W. direction
about 400 feet, although the work is at present confined
tirely to the south face where the quality of the ston
decidedly superior to that formerly quarried farther nor
All the south side of the quarry shows a good, pure, smoo
grained, gray limestone, carrying a very low percentage
silica, and is economically quarried. The rock on the no
side of the quarry varied from 4 per cent. to 12 per ce
in silica, and it would seem as if the change from the s
cious to the non-silicious portion took place south o
clay seam near the center of the quarry and close to a sm
synclinal roll. The beds are not thick, varying from 2
4 feet; but the stone certainly changes color as well as ch
acter going south from the synclinal. The property lin
close to the east side of the present opening, and the e
face itself still shows the synclinal with no decrease in
quality of the stone, although at this point a small a
clinal crimple occurs to the north before the clay seam
reached. The percentage of silica increased rapidly goi
out towards the railroad, where the color of the limest
is a medium blue. The present working face is about
feet high. Some little cleavage, at right angles to the g
eral S. E. dip, is met with, although not to the same ext
as in the line of the synclinal and rolled portion of the
posure.

An excellent face of stone is exposed here under an av
age stripping of about 2½ feet. The product all goes to

Paxton furnaces at Harrisburg and the output is given at about 165 cars, of 16 tons each, per month. This quarry was opened in April, 1886, and may be therefore said to be in the incipient stage of development. One steam drill is used, drilling from 75 to 80 feet per day with a diameter of drill-hole about 2 inches. About 100 yards east of this opening there is an old quarry on the same estate which has furnished excellent stone. It is situated geographically south of the extension of the clay seam in the larger quarry which, as already explained, is supposed to mark the dividing line between the good and indifferent stone. This quarry shows a gentle synclinal on the south side, but dips of 65° to 70° S. 30° E. on the north side. It is not worked.

3. John A. Rutherford quarry.

This quarry lies about ¼ of a mile south-east of Paxtang station, and about 3 miles east of Harrisburg. It was not in operation. The last stone quarried here was about 2½ years ago when it was worked for McCormick & Co.'s Paxton furnaces. The opening is quite large, trending N. E. and S. W. and is situated about 600 feet south of the railroad and on the east side of Spring creek. A siding, owned by Mr. Rutherford, runs some 200 feet towards the quarry; but from that point there is no connection except by wagon road to the quarry face. The cars are stopped at the end of the siding in a cut some 10 feet deep, and the stone is hauled in carts from the quarry to this point. Geologically the quarry is situated apparently a little further south than the McCormick quarry last described, although the intermediate exposures are so few and the change of dip likely to be so variable that in the absence of instrumental locations it is impossible to state whether the stone exposed here can be correllated with the same beds in the more western quarry. Physically it has a strong resemblance to the McCormick quarry stone, having a pale blue to bluish-gray color and is very fine grained. The eastern face of the quarry does not show any regular stratification, the different beds being considerably broken by cleavage; and it is hard to obtain a reliable dip any-

where in the exposure. The general inclination, howe
is to the S. S. E. and a thickness of fully 40 feet of roc
exposed in the south face of the quarry. The capac
when worked, is from 900 to 1000 tons per month wi
force of seven men, although of course. this could b
creased considerably should the demand warrant it.
cost is put down at about 30 cents per ton, there being
little stripping required.

4. S. S. Rutherford estate.

This quarry is ½ mile south of Paxtang station, on
south side of Spring creek. In the fall of 1886 it
leased by Horstick Bros. for lime-burning, the produc
whose kilns, for the most part, goes to Harrisburg for bu
ing, plastering, bricklaying, etc. A small quantity of
inferior burnt lime is disposed of to local consumers
fertilizing purposes. Two kilns, with a capacity of
bushels per day, are operated here, and the burnt l
from them delivered by wagon at Harrisburg for abou
cents per bushel. The field lime sold at the kiln bri
about 7 cents per bushel.

Since the date of lease, April 1st, 1886, some 12,00
15,000 bushels of lime have been burned here, and, acc
ing to the lessees, every 100 bushels requires one gross
of coal. The dip of the limestone is about S. 15° E.
the cleavage being N. 15° W. 55°; the working
about 30 feet high; and the stone of a grayish-blue c
and apparently of good quality.

5. John A. Rutherford quarry No. 2.

This is close to Paxtang station on the north side of
railroad, opened for about 200 feet east and west, para
with the main track and a short distance east from
station. This quarry was abandoned a long time ago.
stone appears to be hard and somewhat silicious, and r
be referred to an horizon coincident with the numer
exposures in the railroad cuts to the west of this local
where all of the stone exposed has, by analysis, been pro

quite high in silica. The bedding in the Rutherford quarry varies from 1 to 3 feet thick in a 25 foot face.

6. Daniel Metz quarry.

This quarry. not in operation, is situated on the south side of the railroad and about 100 feet from it, a short distance east of Paxtang station. The rock exposure here is much broken and the limestone inclined to be cavernous. It has a pale blue to bluish-gray color. Strata from 6 inches to 2 feet thick.

This quarry was opened about 12 years ago, and when actively worked furnished about 60,000 bushels per year, the entire output being converted into lime at the kilns on the north side of the railroad. The best of the product goes to Schuylkill county by rail, and is there sold to the general market. According to Mr. Metz the cost of quarrying and breaking to the proper size at this point is put down at one dollar per 100 bushels, the foreman and two hands being able to furnish 400 bushels a day. Other particulars from the same party served to furnish the following data concerning the working of limestone quarries in this valley, namely: Fifty pounds of dynamite to each 8,000 bushels of stone excavated; drilling is done by hand and a 1 to 1¼-inch hole is drilled each day 8 to 10 feet deep. The extreme length of the quarry east and west is about 100 feet. and the exposed face about 20 feet.

7. Daniel Metz quarry No. 2.

This is situated on the north side of the railroad immediately opposite the quarry last described. This quarry is shallow but the stone is much more regularly bedded than No. 6 and dips about S. 5° W. 25° in beds from 1 to 2½ feet thick. There are three kilns here which burn the entire product of this and of No 6 quarry. The character of the stone exposed is quite similar to that on the south side of the railroad.

8. Private quarry on farm of A. Wilhelm.

This is situated close to and on the north side of the turn-

pike, about ¼ of a mile N. E. of Paxtang station. T limestone is burned here exclusively for Mr. Wilhel own farm, and the quality of that exposed seems very go having a blue-gray color, smooth grained and occurring beds from 1 to 3 feet thick, dipping S. 15° E. 20°.

9. Daniel Metz quarry No. 3.

This is located a short ½ mile N. E. of Paxtang s tion, and about 200 yards north of the turnpike. Th is quite a large opening here which was worked many years, although now abandoned on account of silicious nature of the stone. There are three kilns i dilapidated condition close to the opening. The quarry about 100 feet square and shows a working face on north side of about 25 feet. In structure the exposure somewhat wavy, but shows a general S. W. dip of from to 35°.

10. Daniel Metz quarry No. 4.

This is located about a half mile due east of Paxta station and about 150 yards north of the turnpike. A mu better quality of stone seems to be exposed at this openi which was in active operation in 1886. The stone, ho ever, is of only average quality and is bedded from 1 t feet thick. This stone should be desirable for build purposes or for any object requiring a large-sized stone. is hard and costs slightly more than the average limest to quarry. The opening is about 250 feet east and we and shows a face varying from 20 to 35 feet high. The at the south opening is S. 20° W. 55° and in the east f nearly due south 35°. Four kilns are in active operati the product being used for fertilizing exclusively, burned lime bringing 7 cents per bushel at the kiln. P tions of the exposure show a wavy structure, but the g eral dip is toward the S. and S. W. There are no ex sures or rather openings from this quarry eastward nearly 3 miles to the vicinity of Beaver station.

11. Abner Cassel quarry.

This, an old abandoned opening, lies close to the north side of the railroad about midway between Rutherford and Beaver stations. It has not been worked for many years.

12. Abner Rutherford quarry.

Located immediately west of Beaver station and on the north side of the railroad. This is a large opening showing a very fair quality of stone. It is about 150 feet east and west and nearly the same dimensions north and south, and at the north side shows a face about 30 feet high. The dip in the north face is southward about 30°, but not very regular. Further south, on either side of the quarry, the strata lie very flat. The opening is apparently easily worked and the stripping light. The strata are of varying thickness, some beds being large and massive enough for good building stone. The quarry was in operation in 1886, but usually does not work more than six months in the year. It was leased to Mr. J. H. Walter, who sells all the lime, burned in two kilns, for fertilizing purposes. About ten perches of stone are sold annually for building purposes ; but none of the output is shipped by rail anywhere. About 20,000 bushels of lime are burned every year.

13. Simon Webner quarry.

This is an old opening abandoned years ago, situated west of and not far from the Rutherford quarry and a short distance north of the railroad. The opening was partly closed, and what rock was visible showed a southward dip, and occurred in thin beds.

14 Jonas Allwein quarry.

This quarry is located about 300 yards east of Beaver station and perhaps 175 yards north of the railroad. Though idle when visited it is said to be in operation from time to time all the year round. The kilns belonging to the quarry are situated close to the railroad and on the

south side, where there is a siding for the shipment of t burned lime. The stone when excavated and broken to t proper size, is hauled to these kilns and it is evident tl with this arrangement in force the margin of profit cann be very great, especially as the kilns are situated on risi ground from the quarry.

The opening trends about east and west along the northe slope of a steep bluff and is some 200 feet long with a wor ing face about 25 feet high. Two dips taken here were 23° W. 60°, the other S. 30°. The character of the sto exposed does not call for any special comment. Tl quarry is at the extreme eastern end of the area of lin stone extending from the Susquehanna river, about sev miles to this point, at no point very wide and bounded and S. by extensive areas of slate. The structure of tl limestone area is unquestionably anticlinal, bringing the upper portion of the limestone formation, and in a ge eral way, fairly coincident in strike with the line of t turnpike. The dip is usually to the south in this ar although instances are not wanting of a northern dip alo the margin of the Hudson river slates to the north.

15. John S. Engle quarry.

Situated about ¾ of a mile S. W. of Hummelsto on the south side of the turnpike and on the east bank Swatara creek. The quarry is a small opening and worked to supply burnt lime to the farmers of the imme ate vicinity and to Hummelstown. The opening is on worked from time to time as ocasion demands. The lin stone quarried is of good quality and is considerably us for plastering purposes, bringing 10 to 12 cents per bush The dip is obscure though apparently southward at a gen angle.

16. Charles K. Holler quarry.

Situated about ⅛ of a mile N. W. of Hummelsto town on the south side of Swatara creek and between th creek and the railroad. The opening is about 250 feet wi along the railroad and extends back possibly half that d

tance to a face 25 feet high. The strata vary from 4 inches to 3 feet thick, and the dip is uniformly S. 10° E. 23°. The stripping averages about 3 feet and the stone shows considerable cleavage. Although a considerable amount of stone is sold for building purposes, it does not look any too well for such uses. There are four kilns in operation at the quarry, furnishing an output of from 30,000 to 40,000 bushels a year, which brings from 8 to 12½ cents delivered on cars at the siding. This information was received from Mr. H. Hoffer, foreman. The eight cent lime is used, for the most part, for rough stone and foundation work, much of it by the Philadelphia & Reading Railroad Company. The better grades go to Dauphin, Tower City and Pottsville, Pine Grove, Tremont, etc, largely for fertilizing purposes.

17. Samuel Rutherford quarry.

Situated on the north bank of Swatara creek about ¼ of a mile N. W. of Hummelstown. This quarry is leased to David Heilman and all the stone quarried is burned and sold for farm use only at the kiln. The opening is very narrow, about 200 feet long and with a 20-foot face. The dip is S. 40° E. 20° to 30° and in character the stone is quite similar to that already described in No. 16.

18. Christian Hershey's openings.

These three small quarries all lie about a mile E. S. E. of Hummelstown and almost as far south of the Philadelphia & Reading railroad. The first opening faces and adjoins the branch railroad to Walton's brownstone quarries, and lies a few hundred feet south of the public road and perhaps ¾ of a mile air line from Hummelstown. Here the stone is slaty and finely laminated, dipping S. 40° E. 25°, showing an exposure, looking westward against the steep slope, about 75 feet long and 15 feet high.

The second opening is an older one, on comparatively level ground, perhaps a 100 yards west of the first. This excavation is about 40 feet in diameter exposing limestone over about one-half its area.

The third quarry is at the lime kilns 300 or 400 feet we of No. 2 and a short distance east of Mr. Hershey's hous This quarry was small and was not fairly opened for bus ness.

Mr. Hershey expects to be able to supply stone for buil ing or furnace use as well as large quantities of burnt lin for general market. He had already shipped about 8,0 bushels to Harrisburg for plastering and building, ar claims that his limestone will yield from 97 per cent. to per cent. of carbonate of lime. Moreover he claims that his four kilns he requires only 18 cwt. of coal to 100 bushe of farm lime, and in his quarry requires about 2 lbs. dynamite for every 500 bushels of stone quarried. Son stone is sent to Harrisburg for building; some to Readi for bridges, the run of the quarry being sold for 55 cents perch. Larger and thicker stone for special purposes brin $1.00 a perch.

In all three quarries the dip is toward the S. and S. and a large portion of the exposed faces shows quite a han some, smooth grained stone. The beds do not seem to any thicker than the average through this valley whi rarely get as high as 4 feet; but cleavage was not a pr minent feature, so that a considerable proportion of t stone can be taken out without danger of transverse fractur

19. J. R. Garman quarry.

This is situated about one mile east of Hummelstown, the east side of a small run and north of the pike. Th quarry has not been operated for years. The stone a pears hard though slaty, and dips S. 60° E. 30°. The openi has a crescent shape and is about 100 feet between ends ar with a working face about 20 feet high on the east sid This operation has no outlet to railroad.

20. Union Deposit Furnace Company quarry.

This is a large opening a short distance N. W. of Swata station on the east side of a branch railroad running to t furnace. It may be further located as situated a short di tance north of the pike and east of the public road leadi

to the furnace. The dip throughout is about S, 35° E. 60° and in the entire exposure, which is about 200 feet long north and south, there is possibly 200 feet of limestone shown in successive beds. The working face is from 30 to 35 feet high. The geologically lower beds, occurring at the north end of the quarry are somewhat slaty; but those in the center of the cut yield a handsome blue stone, resembling the Annville stone, only rather more massive and in beds from 1 to 3 feet thick. The best beds are here in the center and yield a combined thickness of about 25 feet. The upper beds, on the south side of the quarry, are broken by cleavage and are neither so pure nor so easily quarried as those in the centre of the cuts. The quarry was idle when visited, but all the stone quarried here is shipped to the Union Deposit furnace when in operation.

21. Samuel Ginrich's quarries.

These openings, three in number, are situated ¾ of a mile N. W. of Swatara station and on the south side of Swatara creek, close to the junction of the Hudson River No. III slates. The first quarry (a) is about 180 feet long and shows a face about 20 feet thick. Limestone at the eastern end of it dips S. 25° E. 45° and at the western end is more massive and irregularly stratified but still dipping in the same direction. In the second quarry (b), immediately east of this and 125 feet from end to end, the stratification is somewhat wavy, the face being about 28 feet high and the dip irregular, especially at the eastern end. The third quarry (c) lies a short distance south of (b) and is about 175 feet long with a working face of 20 feet. The average stripping in all these quarries is about 5 feet, and the stone occurs in layers of from 1 to 4 feet in thickness, but each layer very uniform. In quality the limestone exposed here seems rather superior; but from its location and distance from railroad, the quarry is not advantageously situated for economical development and has evidently not been in operation for some time.

22. Isaac Erb quarry.

This is about ⅛ of a mile north of Swatara station and o the north side of Spring creek. It lies further south tha the Ginrich openings, and in geologically lower limeston es which to judge of their appearance at this exposure, a only of ordinary quality. The quarry is about 125 fe long north and south, and about 22 feet high in the deepes exposure, the dip being apparently eastward. The differ erent strata seemed to be very tightly folded and conse quently hard to distinguish. Three kilns are situated clos by the quarry and when operated evidently only supplie the transient local demand for fertilizing purposes.

23. Zimmerman quarry.

There are several openings extending from Spring cree at the mill southward along the public road to the railroad The *L. Zimmerman quarry* is the first of these and mos northerly, situated about ¼ of a mile N. E. of Swatara sta tion and in the bluff immediately south of Spring creek There is a fine display of good stone at this point which i largely converted into burnt lime. The total thickness o beds exposed is about 60 feet, measured at right angles t a S. E. dip of about 20° to 25°. The beds themselves ar not over 3 feet thick and so regular in stratification as t warrant the belief that a large quantity of excellent build ing stone could be quarried at this point. The stone o top is not quite so pure apparently as that near the road The lower stone breaks out in rectangular blocks and is no so solid or massive as the dark blue beds in the uppe portion of the quarry. The entire output here is sold fo fertilizing and averages from 13,000 to 14,000 bushels year.

24. Widow Landis quarry.

This lies immediately south of Zimmerman's and is prac tically continuous with it. In the 25 feet of vertical inter val between the uppermost bed exposed in the Zimmerma quarry and the bottom bed of the Landis opening, the rock are evidently greatly crushed and folded, concealing stra

tification entirely and producing such an irregular bedding as to prevent economical quarrying of the stone. The Landis quarry stone is quite massive and of better quality near the north side where the beds are deep blue in color and can be faintly identified with the upper and best beds of the Zimmerman exposure. This property is leased by William Rennison, of Norristown, who uses the three kilns of Isaac Erb's quarry for the purpose of burning his lime. The dimensions of these kilns are 6 feet diameter at bottom, 13 feet at top and 20 feet deep with a capacity of 1,500 to 2,000 bushels when filled. About 2,800 bushels of lime are reported as the output per week, which is shipped to points in Massachusetts, New Jersey and Maryland and is used for chemical purposes.

Further details of the industry at this point show 18 hands to be employed, at 12 cents an hour, with 6 horses and carts. Black powder is used for blasting, requiring about 80 cents worth for every 100 bushels of lime. It costs 2½ cents per bushel to quarry the stone and 10½ cents per bushel to put the lime on the cars at siding some distance away, at which rate, after paying a royalty of ½ cent per bushel, the profit is small. South of the crushed portion of the Landis quarry the limestone dips about 45° to the S. E. and is there quite as regular in its bedding as in the Zimmerman quarry.

25. William M. Kauffman & Co.

This now abandoned quarry is immediately faces the two last described openings, on the east side of the public road. All the stone quarried here went to the Sheridan furnace on the Lebanon Valley railroad; but this plant has apparently abandoned the use of this stone for the superior deposits in the neighborhood of Annville. No new features are presented in this extensive exposure, which must be 200 or 300 feet long and shows a face some 18 or 20 feet high. The beds are largely the same as those exposed on the opposite side of the road; some excellent, some good, while some are only fair to indifferent. The dip throughout is to the S. E.

stripping. The stone is sold here for from 60 to 65 cen per perch, or from 90 to 95 cents per perch delivered cars at Palmyra station or Derry. This quarry is the la opening in the vicinity of the railroad in Dauphin coun and is within ½ mile of the Lebanon county line.

Lebanon county.

33. John Gruber and Simon Bowman quarries.

A series of rambling openings and kilns located half mile S. W. of Palmyra station and a short distan from the Dauphin county line. In these openings there a stone very similar in appearance, quality and structu to that exposed at Shenk's quarry last described. T stone is well adapted to building purposes and is also co verted into a good quality of lime and sold for farm use.

34. Shenk Bros.' old quarries.

Two small quarries now abandoned, situated about miles north of west from Annville. The stratification he is rather vague and the stone has a harsh blue color not attractive as that exposed further eastward in the gre Annville quarries. In each opening there is about a 10-fo face exposed and the dip is southward about 65°. Th quarry is without railroad connection.

35. Batdorff and Beaver quarry.

This is the first of a series of notable limestone quarri lying to the west of Annville and furnishing the well-know "Annville stone." This quarry is situated about 1 miles N. W. of Annville on the north side of the railroa with which it is connected by a siding and on the south sid of Quitapahilla creek. There is a very large and irregula opening here displaying an almost inexhaustible quantity o excellent stone. The best stone quarried is in the center o the cut and along the north side. The south side is some

what slaty. The dip is nearly uniform and steeply S. E. and S. W. The stone is blue in color and soft in texture and in the old quarry probably 250 feet in thickness would be suitable for quarrying. The dimensions of the quarry are hard to give on account of its irregular shape: but the opening is fully 300 feet long and shows a face in places 40 to 50 feet high. The dip, as before stated, varies from 40° to 70°. The entire output here is about 2,300 tons per month, all of which is consigned to James H. Kreider of Annville, who in turn ships to the Cornwall and Robesonia furnaces.

36. H. & J. Kreider's quarry.

This lies immediately east of Batdorf & Company, and is practically opened in the same strata of stone, which is rather massive and solid throughout. There are no slaty layers shown in this opening, perhaps because it has not been developed quite so far south as Batdorf & Company's quarry. There is a peculiar joint in the center of the east face, breaking an otherwise uniform S. E. dip. Only a small low knob of stone yet remains to be quarried on the west side of the opening within the limit of the property lines, unless the quarry is opened to a lower level. The beds are not over 4 feet thick, somewhat brittle, but of excellent character. The opening is about 250 by 175 feet, showing a 5-foot stripping over a 10-foot face at the north side, but comparatively little on the remaining three sides, where on a S. E. dip of from 12° to 45°, the quarry has been developed to a depth of 30 feet. This quarry has evidently been worked for many years and the stone furnished had always maintained a high reputation for chemical and other special purposes as well as for furnace flux. The four kilns supplied from this quarry produce on an average about 5,500 bushels of lime per month, which is largely shipped to Powers & Weightman of Philadelphia, and the Pennsylvania Salt Company.

An allowance of about 6¼ tons of stone to every 100 bushels of lime is made in burning and the best record of the kilns shows 1,700 pounds of coal to 100 bushels of burned

lime. The amount of stone used for flux quarried at t opening averages from 800 to 1,000 tons per month anc put upon the cars at a stated cost of 31 cents per ton. I J. H. Kreider controls the sale of stone from six quarries namely, Batdorf & Company, Light & Houser, Andr Kreider, Wm. Beaver, and S. L. Brightbill which, with own quarry, make a total output of over 5,000 tons month from which the Bird Coleman Furnaces Nos. 1 a 2, North Cornwall, Donaghmore and Robesonia furna are supplied.

37. S. L. Brightbill & Sons' quarry.

This consists of two very large and extensive openi about 1¾ miles N. W. of Annville and on the north side the railroad. These openings are immediately east of t Kreider quarry last described and show about the sa features upon a more extensive scale. The stone n quarried is almost identical with that in Kreider's, showi an excellent fine-grained, soft blue-gray limestone in sm beds, breaking out in somewhat brittle masses. The ge eral dip is rather steeply S. E. although in places it is qu irregular. In the large opening between the siding and t public road, the structure is quite wavy at the west si but is much more regular upon a dip of S. 40° E 60° to ' as the opening narrows towards the public road brid The larger cut is probably 400 or 500 feet long and is ratl pear-shaped with the stem faced towards the public ro The quarry track has been extended from the kilns on t west to and beyond this road, while a distinct and separ siding leaves the main road to the east of the wagon ro and is projected to join the larger quarry in due time. S far this second track has been run a couple of hundred fe in a narrow cut about 25 feet deep, there having been e dently little intention of developing this side of the quar Taking the quarry as a whole, the south face, 35 feet thic shows a stone somewhat ribbed, and the crush in the quar is about on line with the disturbance already noted in t Kreider opening. The total thickness of rock exposed about 50 feet.

The first opening made here was about 25 years ago and for the first five years the quarry was only worked to supply one kiln, the product of which was sold for farm use. In the fall of 1886, there were six kilns in active operation, producing commercial lime, most of which was shipped to W. F. Bradley, Philadelphia. About 15,000 bushels are produced here every month. The kilns 6 × 25 feet have a capacity of 400 bushels each, and draw 125 bushels per day. It is stated that about 1½ tons of coal are required for each 100 bushels of lime. The stone is quarried by contract and put at the kilns ready for burning at 18 cents per ton. Fluxing stone was being furnished in 1886 to the Sheridan and Cornwall furnaces, 50 tons a day to each place, for which 41 cents per ton was received at the quarry. At that time about 25 men were employed as well as a small locomotive and a 40-horse power stationary engine; the latter being used to run the vats and reels. The vats are utilized to slack the lime, the reels to screen, pulverize and refine the product (like flour) for shipment in bags for chemical and manufacturing purposes. The reels are 3 feet in diameter and 20 feet long; the agitator vats are 10 feet in diameter and 4 feet deep. All the hauling is done by locomotive, and computing the connection with the main line of railroad and the numerous sidings to various parts of the quarries, there is probably one mile of track laid here, with grades varying anywhere from 7 to 100 feet. The locomotive weighs about 11 tons. About 200 pounds of dynamite are used per month at this quarry and one steam drill. It was stated by the foreman that in burning this stone it loses about 40 per cent. in weight and about 10 per cent. in bulk.

No. 38. William M. Kauffman & Co.'s quarry.

Lies on the north side and close to the railroad and about 250 feet from the creek. The opening, which is the most northern of two, shows a stone occurring in strata from 1 to 1½ feet thick very regular and with uniform dips of S. 10° W. 25° to 30°.

39. Quarry No. 2.

The second and most southern quarry of the same f lies immediately south of the railroad and a little furt east of the quarry last described. This quarry is connec with the main line by a lateral spur running off from the m siding extending south across the creek to the Beaver a to the Light & Houser quarries. The Kauffman openin about 200 feet from the railroad and about 150 feet wi north and south. There is probably a 20-foot face expo here, the stone being very finely laminated, and dipping S. E. 20°. The dip is very gentle throughout, though in pla it seems to incline to the S. W. The beds are neither m sive nor thick, and are more gray in color than the us Annville stone. From these two openings from 3,000 4,000 tons of stone are shipped per month to Sheridan a Reading; but only about 1,500 tons had been taken fr the quarry on the north side of the railroad.

40. William Messner's quarry.

This is an old opening just north of the pike and ab one mile west of Annville. The quarry is just east of farm house and has evidently been abandoned for so time. The stone is apparently lean, finely liminated, a altogether below the general excellence of the Annville posits. The dip is gently S. W.

41. Light & Houser.

This small and new opening was scarcely developed su ciently, when visited, to warrant any opinion as to the ch acter of the stone to be eventually quarried.

42. J. W. Beaver quarry.

This is an old and large opening between the creek a the turnpike, about ¾ of a mile west of Annville and c nected with the main line of the Lebanon Valley railro by a siding already described. The opening is possib 600 to 800 feet long, and extends in a south-easte direction from the creek back to the pike. The dip

everywhere very gentle to the S. E. and S. W. There is a small roll exposed close to the creek, where about one-half of an anticlinal saddle is left exposed on the south side of the axis. Immediately south of this the dip is as steep as 35°, but sags up rapidly approaching the turnpike where it is scarcely 10 degrees. It is quite probable that this quarry is in slightly different stone from that occurring in the Batdorf and Kreider quarries first described, although it may have been duplicated by structural features concealed now along the creek. At all events it is geographically considerably further south. This large quarry produces farm and chemical lime, besides a large quantity of stone for fluxing purposes, the latter (about 80 tons a day) being shipped to Sheridan and Topton. All the burnt lime in the fall of 1886 was shipped to Charles Warner & Co., Wilmington, Del., that company taking about 1,000 bushels a month for use in the manufacture of paper. There are five draw kilns, 6 × 26 feet with a capacity of 150 bushels per kiln, four of which are always kept in active operation. It is stated that it costs 85 cents per 100 bushels to quarry and break stone and deliver it at the tunnel head at the kiln ready for use. This work is let by contract, Mr. Beaver furnishing powder and tools. The stone that is furnished for fluxing purposes is sold on cars at the quarry for 41 cents per ton, and is said, like all other stone in the quarry, to contain from 96 per cent. to 98 per cent. of carbonate of lime.

43. Light & Houser quarry.

This is the nearest opening to Annville, being situated a short distance south of the creek, and connected with the general siding leading from the Beaver quarry, which it almost adjoins on the east. This quarry has recently changed hands, and is now worked by Melfer and Forney. The stone exposed is of excellent quality, but in general it appears to require rather too much stripping to be economically worked. The opening is very irregular, there being quite a long cut made in the side hill before the good stone is reached at the south end of the quarry. Here the face had been opened for a width of 75 feet, and was from

18 to 20 feet high. The limestone has a slight cleavage this point, and slips dipping about 75° N. 80° E.

On the north side of this rear excavation, the dip is parently westward at about 25°, and still further nor nearer the creek, the dip has changed to S. 10° W. 25°. stone has a deep blue color, and in the quarry show number of thin layers with some few beds of good thi ness. Cleavage is rather a prominent feature through this opening.

44. Kreider's quarry.

A small quarry owned by H. Kreider, opened on the sou side of the turnpike, about a half a mile east of Annvil The quality of the stone at this point seems quite go and dips rather steeply toward the south. One kiln is us here for burning the stone, which is disposed of for lo farm use.

45. Frederick Yake quarry.

Situated on the south side of Quittapahilla creek, about miles east of Annville. This is only a small quarry open for local use. There are two kilns here for burning lin and Mr. Yake states, that when actively worked, he c draw 250 bushels of lime per day from both kilns.

46. Andrew Kreider's quarry.

A new opening situated between the railroad and turnpike, 1¼ miles east of Annville. This quarry opened about a year ago and produces a good furnace sto It is connected with the railroad by means of a siding, a shows an opening about 100 feet east and west, and 90 f north and south, and with a face 20 feet high The qua is worked to produce fluxing material exclusively, and f nishes about 15 small car loads per day, which is shipp to destination through the hands of Joseph Kreider Annville. The stratification of the stone was exceedin irregular and wavy, and is especially broken towards south face, where, however there is 30 feet of good bl gray limestone exposed. The stone really looks better h than on the east side where work was being carried on

shipments to Robesonia. The stripping is quite heavy throughout, and is thickest on the east side. The dip at the south face is about S. 10° W. 12°, and in the west face S. 60° W. 15° to 20°.

47. *Robert H. Coleman quarry.*

Situated on the south side of the Reading railroad, immediately west of Colebrook furnace and about two miles west of Lebanon. An enormous amount of work has been done here, so much in fact as to change the topography over a very large area of ground. All the different strata of limestone exposed in this opening seemed to lie very flat, but generally dip gently southward. The material quarried is of excellent quality and bedded in such a manner as to admit of economical excavation. Steam drills are very largely used in the quarry, and the entire output is consumed by the Colebrook furnaces. No information could be obtained as to the total output per year at this opening; but inasmuch as the entire flux for the Colebrook furnaces comes from this one opening, the total tonnage must be very large.

48. *Brock Bros.' quarry.*

This quarry of the North Lebanon furnaces is a large opening situated on the south side of the old canal, south of the furnaces and north of the Reading railroad. A very extensive cut had been made at this point also, which may be roughly put at 400 × 500 × 40 feet deep. Steam drills and the latest appliances for quarrying are used, and the entire output of the quarry is consumed in the North Lebanon furnaces. The general dip of the strata is S. 20° W. 20°, and the total thickness of beds, one to four feet thick, is about 35 feet. In places the structure is somewhat wavy, but in the south and east sides of the quarry, where the present work is carried on, all the strata dip regularly southwards and are very evenly bedded. The quality of the limestone is superior, although, perhaps, not quite so free from silicious matter as the stone obtained from the

Annville district. In color the stone varies from a light gray to a pronounced blue.

49. *Meily and Brother quarry.*

This is situated immediately south of their Lebanon furnace and within the western limits of the city and just south of the railroad.

A very extensive opening has been made here, begun about eighteen years ago, and presents an exceedingly handsome face of stone, particularly along the north side of the main cut, and dipping gently 15° towards the S. W. The natural stripping is rather heavy ; but the quarry has been so largely developed (400 × 100 × 30 feet) that excellent massive stone can be quarried through a larger portion of the area excavated. At present, work is carried on almost entirely on the north side, and in character the limestone shows a blue-gray color somewhat lighter than the Annville stone, occurring in thin and massive beds from one to three feet thick, and quite free from silicious material. Quarrying is done here by contract at 30 cents per ton, and only one steam drill was being used to supply the furnaces with their necessary flux. Probably 1200 tons per month are used from this quarry and entirely consumed in the Lebanon furnaces.

49 (*a*). *Gloninger estate quarry.*

This is now in the hands of Dr. Andrew Gloninger, of Lebanon, aud leased to Mr. J. Shark. This opening is a small one, located about one mile west of the center of Lebanon, south of the turnpike and on Quittapahilla creek. There are two kilns of 500 bushels capacity each used in burning lime, each of which draws 200 bushels per day. The cost of quarrying and breaking stone ready for the kiln is put down at one cent a bushel, and the lime is sold in two grades at 12½ cents for picked lime, and 6 cents per bushel as it comes from the kiln. Dips taken here are southward from 45° to 25°. All the lime furnished is sold for local use in Lebanon and the immediate vicinity.

50. *R. W. Coleman's heirs' quarry (abandoned).*

This is situated just west of the Cornwall railroad, near Donaghmore furnace, where all the material formerly quarried was consumed. This quarry was a steep side hill operation and the limestone has been but sparingly quarried, and all dips southward.

51. *S. S. Horst quarry.*

This is a very old opening, situated immediately north of the old Union canal on the east side of Seventh street in the N. E. corner of Lebanon. The opening is 150 × 250 × 40 feet deep, and is equipped with two kilns 6 × 15 feet, with a capacity of 275 bushels each and drawing 125 bushels each per day. The yearly output here is given as 35,000 bushels, sold at from 12 to 15 cents for picked lime, delivered in Lebanon, and 4 cents for slaked. The product is used chiefly for plastering and brick work in and about Lebanon. The picked lime is largely used for stone and foundation work. The rock is of good quality, with beds from one to two and one-half feet thick, and dipping westward about 35°, although in places the dip varies to the south.

52. Quarry, or rather a brick yard excavation exposing limestone, about 1,000 feet east of Horst's quarry, and on the same street. The dip here is about S. 25° W. 35° and the exposure unimportant.

53. *Fritz quarry.*

A large and deep opening now abandoned, but opened many years ago. The two kilns here, however, are used and supplied with stone from Wagner's quarry in S. E. Lebanon. The Fritz opening shows a blue-gray limestone, without regular dip, and with cleavage planes inclining westward about 70°. The opening is about 275 feet long and 20 feet deep; the stripping rather heavy and irregular. The lime burned in the kilns is sold for use in the town of Lebanon. The quarry is situated east of Fifth street, and south of the old canal bed.

54. Shenk and Herr quarry.

This is leased by J. Wise. It is an old openi equipped with two kilns burning lime for use in the tow The capacity of the kilns is 275 and 125 bushels. Abo 200 bushels are drawn every day and sold for plasterin building and farm use at from 5 to 14 cents per bushel. T opening is roughly crescent-shaped, perhaps 150 feet fr end to end, 75 feet wide and 20 feet deep. On the w side, near the kilns, the dip is westward about 15° ; on t east side immediately opposite, about 55° to the southwa The beds are usually thin and the stone of not conspic ously good character.

55. John Wagner quarry.

This is situated in the S. E. corner of Lebanon, a largely worked for furnishing building stone to Leban Its dimensions are about 160 feet east and west and 100 f north and south, the north face being about 20 feet hig The dip is about S. 30° E. 35° and the beds quite massi

56. A. Houck quarry.

Situated near the southern limits of the city, a not in operation. The stone appears to be of good quali of a blue-gray color, and dips about S. 30° E. 35°. T quarry is about 100 feet long and 20 feet deep.

57. Quarry (ownership unknown).

Situated a short distance S. E. of No. 56 and r in operation. The opening appears to have been made furnish building stone exclusively, which is of a moderat good quality. The opening is about 250 feet east and we and shows a face 18 feet high. The dip is to the S. E. fr 20° to 30°, and the stone is finely laminated and would se to be economically quarried.

58. James March quarry.

Situated a short distance west of the two last d described openings, and connected by siding with the Co

wall and Lebanon railroad. The opening is about 175 feet north and south, and with a face 35 feet high. It was idle when visited in December, 1886, and is reported to have been worked to supply both fluxing and building stone, although the destination of the material was not known. The dip is S. 50° E. 20° in blue-gray limestone, not thickly bedded.

59, 60. R. W. Coleman's heirs' quarries.

These are situated on the west side of the Cornwall railroad, about ¾ of a mile south of Lebanon. They are two immense openings, started many years ago, but now abandoned. Each is connected by a siding with the main railroad, and together they make practically one development for a distance of 1800 feet along the track. They were formerly worked exclusively to supply Cornwall and perhaps Donaghmore furnaces with fluxing stone. The material, however, was too hard and lean for furnace use, and has not been used for a long time. The most northern quarry extends out from the main railrond for about 250 feet, and on the west side shows a face 25 feet high, the rock all dipping southwards about 35°. The south quarry is about 325 feet in width, showing a long cut north and south through which the siding extends. There is a face of 35 feet at the south end, and the rock all dips southward at angles of from 35° to 50°

There are no developments of moment along the Lebanon Valley railroad for several miles further east, and the quarries at Lebanon are largely kept in operation by the local demand for fluxing and building stone at that point.

61. John A. Beckley quarries.

Situated 3 miles S. W. of Myerstown, and one-third of a mile S. E. of the railroad at Prescott station. They are the first openings east of the Lebanon quarries already described. There is a series of small and scattered openings at

this point, all of which furnish stone to one kiln, 14×
feet, and with a capacity of about 250 bushels, drawing
bushels per day. It is stated that stone can be quarri
here at 5 cents per hundred bushels, and the lime made
sold to farmers for field use at 8 cents per bushel. A co
siderable amount of broken stone has been furnished to t
turnpike company for road use, delivered from one to one a
a half miles for $1 per one-horse load. A great deal of sto
from small openings on this farm has been quarried a
converted into lime, and the openings thus made have be
since covered up and farmed over. For this reason a ve
limited exposure of rock is to be seen at any one pla
and the quarry can hardly be considered a well develop
one.

62. *Samuel Urich quarry.*

This is situated about 2¼ miles west of Myerstown, alo
the bed of the old Union canal. It is a large, ramblin
irregular opening, several hundred feet long east and we
and perhaps 200 feet wide at the widest point, near t
eastern end of the quarry. Several small openings ha
been made on the south side of the canal, to the east a
west of the lock, one of them on the west being abo
100 × 50 × 15 feet deep. At this latter point the limesto
rock dips S. 20° E. 60°; in the north face of the main quar
15 feet high, S. 25° E. 57°; and in the small opening, t
most eastern of the exposures, the dip is S. 15° E. 55°. T
stripping in the main quarry is uniform and rather heav
The stone appears to be quite good, and is quarried e
clusively for fluxing purposes and shipped east ward. B
little additional information could be obtained concerni
the destination of shipments.

63. *Valentine Urich quarry.*

Situated on the south side of the turnpike, we
of Myerstown. The opening describes about a half circ
with a diameter of about 70 feet and a face of 18 feet on t
east side, where the dip is S. 15° E. 55°. There are tw
kilns here used in burning lime, and about 3,000 to 4,0

bushels are produced in a season for farm use. The stone is good, though quite hard, and bedded in strata from 3 inches to 2½ feet thick. It is easily quarried and some of the best building stone observed anywhere in the Lebanon valley occurs at this point, notwithstanding the fact that the beds are rather thin. A considerable proportion of the outcrop is used for building purposes, and an average two-horse load is sold for 75 cents, or 75 cents per perch, measured in the wall, if the purchaser comes for and loads his own stone.

64. Salutus Bassler quarry.

This lies a short distance east of No. 63, and within the borough of Myerstown. The quarry was not in operation. There are two kilns of 400 and 350 bushels capacity and 35 years old, from which fact an idea can be obtained of the age of this quarry. As high as 45,000 bushels per year have been burned here; but during 1886 only about a tenth of that amount was produced. The quarry is about 250 feet north and south and 150 feet east and west, and in places shows a face 20 feet high. On the west side the dip is about S. 22° E. 32°; at the north end, the same direction at about 45°, while the dip is still steeper on the east side. All the lime burned here is used for farm purposes and is sold at 8 cents per bushel.

65. Jonathan Miller quarry.

This is an opening near the Union canal, immediately south-east of Myerstown. The quarry was not in operation and shows a thinly laminated and slaty limestone dipping towards the S. E.

65 (a). Isaac Miller quarry.

This has been recently opened on the opposite side of the canal, from which all the stone obtained is shipped to Reading and burned there for plastering purposes. The dip at the north side of this quarry is S. 10° E. 20° and the quarry was hardly sufficiently opened to warrant an opinion on the character of the stone to be developed.

66. *John and George Donges quarry.*

This is leased by E. Walburn, is situated immediate east of No. 65, on the north side of Union canal and open in a bluff at that point, a short distance south-east Myerstown. A small anticlinal arch is visible in the nor face of the quarry, which is 22 feet high, the entire openi being 250 feet from end to end. The limestone exposed not of the best, being thinly laminated and with occasion slaty and impure beds. There are two kilns operated connection with this quarry, with a capacity of 300 bush each. The stripping is light, and the dip of the rock sout ward at angles of from 20° to 35° east.

67. *Samuel C. Royer quarry.*

This is situated on the south side of the railroad, abo one mile east of Myerstown station. The extreme leng of this opening along the track is about 300 feet; the face 20 feet high, and the dip southward about 10°. The rock curs in beds from 6 inches to 3 feet thick and shows a u formly good quality of stone for building and curbing pu poses.

68. *John Hartlieb, lessee.*

This is a quarry on the south side of railroad, one and quarter miles east of Myerstown and not far east from N 67. It had been only recently opened, and operatio tions had been suspended during the winter season. T stone is particularly well adapted to curbing and paving, well as for light building purposes. There are several sma openings at this point, the limestone cropping near t surface and is readily quarried. The dip varies from 10° W. to S. 20° W. and in strength from 10° to 15°.

69. *Adam Loose quarries.*

These are two small openings on the north side of t railroad and a half mile west of Richland station. Neith of the quarries were in operation when visited. The larg of the two lies about 600 feet from the railroad and is abo

75 feet in length east and west. It shows a 20-foot face in which the stone dips S. W. 15°. No siding exists at this point, although most of the stone quarried here was formerly shipped to the Sheridan furnaces.

70. The William Landis quarry.

This is operated by Mr. Boyer. It is an old and large opening, located immediately north of the railroad near Richland station, and when operated the entire product is shipped by railroad to Tamaqua, Schuylkill county, to be there converted into lime. The stone exposed seems of fairly good quality, but the beds were somewhat broken and vary in thickness. The dip is S. 25° W. from 15° to 20°.

71. Shaeffer and Yingst quarry.

This consists of a few rambling openings, just opposite No. 70, and on the south side of the railroad near Richland. The quarry was not in operation; the stone exposed is hard and silicious and the bedding very irregular and much disturbed. No great amount of limestone was ever taken from this opening and all the output was apparently consumed in one kiln on the ground.

72. Kauffman & Co.'s quarry.

This is quite a large opening, situated a short distance south-west of Richland, on the west side of the public road. The quarry was abandoned years ago, on account of the slaty nature of the stone. The dip seems nearly S. 15° W. varying from that to nearly due west and inclined about 25°.

73. George J. Eckert quarry.

Is a small opening located on the map at a short distance west of Sheridan. The exposure here is poor and the quarry of small size.

74. Catharine Gehret quarry.

A small quarry made for building stone, opened on the west side of a steeply sloping hill, a short distance

east of Sheridan furnace. The quality of stone expos
here is only fair, and the opening is very insignificant.

75. *Kauffman & Co.'s quarries* (*abandoned*).

Are situated a short mile south of Sheridan stati
and formerly worked for the purpose of supplying flux
the furnaces there. The stone was found to be very le
and slaty, and altogether unsatisfactory as compared w
the Annville stone now used at the Sheridan furnaces.

Berks county.

76. *William Moore quarry.*

This is a small opening situated on the north side of t
railroad, a short distance south west of Womelsdo
in Berks county. This quarry shows stone of a medi
quality, in strata from 6 to 18 inches thick. Th
is a considerable amount of stripping and much earth
curs through the exposure, rendering the rock slaty a
impure in places. The color of the rock is very dark-bl
and though the beds are thin, some of it would apparen
do very well for building purposes. The dip of the lin
stone is S. 10° W. 35°.

77. *John Marshall quarry.*

This is a small quarry just north-east of Womelsd
station. It is worked occasionally to supply railroad b
salt, and the stone is only of ordinary quality, dippi
southwards about 60°.

78. *Old abandoned quarry.*

Located on the north side of the railroad and east
Womelsdorf station, showing only a limited amount
limestone rock, dipping south-west about 85°, and qu
unimportant in its bearing upon the commercial aspects
the region.

Notes on the Geology of Radnor township, Delaware county, Pa., and of the townships adjacent to it.

By Theodore D. Rand.

The area under study comprises parts of Radnor, Haverford, Newtown and Marple townships, Delaware county; part of the adjacent townships of Lower Merion, Lower and Upper Darby, Montgomery county; Easttown and Tredyffrin, Chester county, and of Philadelphia. In portions of these notes these townships will be designated by their initial letters. Where an outcrop is referred to and the nearest named place is in another township, it is the township of the *outcrop* that will be given.

The bearings given were taken by compass on the ground, but allowance was made for magnetic variation.

The indications on the map are placed with reference to roads and streams as drawn on map of Philadelphia and Delaware counties, published by G. M. Hopkins & Company, 1876; but the location of some of them does not strictly accord with my observations on the ground.

Where a rock seemed almost unquestionably to be continuous it has been so represented. In cases of doubt outcrops only are given.

The region mapped having been long under cultivation, and being a region in which decomposition of the rocks in place has gone in many parts to considerable depths, it is impossible to define the limits of the belts with accuracy, and those given on the map must be regarded as merely close approximations. It is very probable that the Serpentine, the Potsdam sandstone, and the white sandstone S. E. of the Laurentian (probably Potsdam) are continuous, but as this is not certain, actual outcrops only of these rocks are given. In some cases the outcrops appear to be very narrow, and it has been necessary to somewhat exaggerate their width in order to show them at all, but I have endeavored to represent them as nearly as possible, exactly as they are.

There is great need of an accurate topographical ma this region. The maps used as the base are probabl error in many places, but nowhere seriously so. To a indistinctness it has been necessary to omit many m roads and places.

The region is generally a rolling table land, ranging do ward from about 480′ A. T. The most prominent featu the range of Laurentian granitic and syenitic gneiss, ext ing south-west from east of the Schuylkill river beyond limits of the area under study. This hill forms a pr nent feature of the landscape throughout almost its w extent. The rock is exposed in many places, but proba best at the gap through which the Schuylkill flows. structure appears to be anticlinal. The rock, where decomposed, is very massive, in thick beds, and cont quartz, feldspar, hornblende and mica in varying pro tions. The quartz, feldspar and hornblende each in s places make a large proportion of the rock, at others t are more evenly intermixed. The mica (biotite?) is ge ally small in quantity. Garnets occur, but not abundan

The characteristic mineral of the formation is blue qua which occurs almost everywhere. Indeed, after a rain almost every road may be detected unrolled fragment this quartz. The gneiss appears to be traversed by nu ous dykes of dolerite, but I know of none which have b traced for any distance. Where visible they seem to h been eroded or decomposed equally with the syenite.

The concentric weathering of this rock, like that of porphyritic belt hereafter referred to, gives rise to boul like masses, at times in place, at others strewn over fields, as if waterworn and transported. This weathe was well shown when the cut of the Pennsylvania railr east of Radnor Station (R.) was widened. Here as m as twenty concentric coats around an unaltered nucleus w visible, and the same structure can still be seen in a degree. This weathering changes the hard massive gn into thin fragments, sometimes friable, but often q hard and then resembling a schistose gneiss. Those p tions which were hornblendic, appear to have decompo

most completely and to have become a reddish-yellow sandy loam. Many of the quarries in this gneiss show this weathering, which often extends but a few feet; the rock being almost schistose near the surface, but massive and compact twenty feet below.

From the Schuylkill, south-westward, outcrops of this rock are almost continuous. Its boundaries are well defined by the steep slopes which mark them on both the south-east and north-west. The belt widens from a little over a mile at the Schuylkill, to two miles at the Delaware–Montgomery county line, and to nearly four miles at the south-west line of Radnor township. The slopes become more gentle as the floor of the valleys adjacent rise to the Delaware-Schuylkill watershed, which is nearly the line of the Pennsylvania railroad.

About 2000 feet N. E. from Villa Nova station, is a quarry (L. M.) on the property of Estate of E. H. Curwen. The western end shows a small anticlinal; the eastern, a folding, the dips being steep south-easterly on the north, almost horizontal in the middle, steep south-easterly on the south, bounded on the south-east by a bed of very massive hornblende-like rock, possibly a trap dyke. The lower portions are massive and heavy bedded; the upper, schistose from decomposition.

Along the line of the Pennsylvania railroad, going westward, the rock is first met in an old abandoned quarry, about 1,200 feet north-north-west from Rosemont station (L. M.) Immediately north-west large masses lie along the embankment of the old Columbia railroad, a loop of which remains on the east side of the present roadbed. North-westward of this to Villa Nova station (R) about 0.9 miles the cuts are slight, and the rock greatly decomposed, but in the county line road, about 0.5 miles north-north-west of Rosemont, and close to the railroad, an outcrop may be seen. The same rock was found in the well on property of H. F. West, 0.4 miles north-north-west of Rosemont. West of Villa Nova, there is a cut some thirty-feet in depth, where the rock is much decomposed; at the westerly end near Upton station, (R.) the dips are 45° and upwards south-

easterly, becoming steeper eastwardly, until they bec
nearly or quite vertical.

About 1000 feet north-west of Upton station (R.),
quarry on the property of Israel Morris, on the line of
old Columbia railroad and north of the Pennsylvania
road. The rock is a massive, highly feldspathic sye
unaltered. The dip is uncertain, but probably 45° ± S
E. Between this and Radnor station is a cut about tw
feet in depth, through decomposing Laurentian, which
be better seen in quarries on the line of the Columbia
road, which here curved to the south. The rock is
massive below, schistose from decomposition above,
steep S. 30° E. ± 80° ±.

In this cut is a dyke of dolerite (analyzed and determi
by F. A. Genth, Jr., C[5], p. 115), and when the road-
was widened, several small dykes, probably also dole
were apparent, dipping steeply to the southeast, and cut
granitic dykes dipping steeply north-west. In one ca
tongue of the trap was intruded between the layers of
gneiss nearly at right angles to the dyke. See plate p. 1

At Radnor station is the source of Harding's ru
branch of Ithan creek. It occupies a marked depressio
the gneiss, characterized by numerous small spring
water. Comparatively shallow wells in the vicinity h
long been noted for their abundant water supply. T
location was taken advantage of by the Pennsylva
railroad, which many years ago established a pump
station and water tanks near by. For a long t
the flow of the springs and the supply from a w
together with some storage in a dam, afforded an am
supply, but with the increased traffic, more water
needed. About 1878 an artesian well, 12 inches in diame
was begun. At a depth of about 40 feet, undecompo
Laurentian gneiss was struck. Progress was slow
difficult. At one time, in a stratum containing inter-mi
pyrites, by 140 hours constant drilling only fourteen inc
in depth were gained. At about 500 feet (probably ab
100 feet below ocean level) the hole became crooked and
well was abandoned. It was almost perfectly dry. Sub

quently a second well was begun, only about 50 feet in a northerly direction from the former, and was drilled of a diameter of about 12 inches, to the depth of 500 feet, and of 8 inches to the depth of 975 feet (about 575 feet below ocean level). From this well, 40 to 50 gallons of water per minute can be pumped, but it is questionable whether it is not surface water, and not from any deep stratum. This supply being insufficient, after other unsuccessful experiments, ten wells were sunk near by, in a space of about 150 × 200 feet, by driving an eight-inch steel shod pipe to rock; the pipe was kept clear by a sand pump. When rock was reached a perforated pipe of smaller diameter was inserted, and the outside tube was then withdrawn.

The strata passed through are reported.

Surface soil,	4′
Clay, blue, sometimes yellow,	7′
Gravel (?) and sand to rock,	29′ to 44′
Total to undecomposed rock,	40′ to 55′

The "gravel and sand" are without doubt the decomposed Laurentian.

These wells were tested by continuous pumping and the ten yielded 200 gallons per minute, or 288,000 gallons per day for a period of two weeks, and after the lapse of a year, in a dry time, were again pumped at the same rate for two weeks.

A remarkable fact in regard to them is that while pumping from the ten, if one be shut off from the pumps, the water will immediately rise in it to within 8 or 10 inches of the surface, although the remaining nine are being pumped to their full capacity.

The large well referred to is twelve feet in diameter and thirty feet deep. It (the second artesian well) and the ten driven wells are connected with pumps capable of forcing 700 gallons a minute into the tanks. The wells furnish this supply for from two to three hours, when the tanks being full, pumping ceases. The present consumption is about 120,000 gallons per day.

The stream, originally fed by the springs, was quite small. I am told that it would not have filled a two-inch pipe.

There are no large springs in the vicinity. The total area draining towards this pumping station, which is only about 500 feet south of the watershed (Darby creek and Schuylkill river), probably does not exceed 50 acres. The source of this large supply of water therefore seems obscure, as well as its outlet before the pumping was done.

About 1300 feet north-west of Radnor station, is a small cut. Here the rock is Laurentian, in part massive and unaltered, and in part wholly decomposed. Three thousand feet N. W. of Radnor station is a larger cut, in which most of the rock is unaltered. At this point its hardness is so great, that in the widening of the cut, it was found more economical to blast by dynamite laid upon the surface and exploded, than to drill it, and most of the blasting was done in that manner.

The Lancaster turnpike runs near and approximately parallel to the railroad. It has been so settled for many years, that outcrops that may have once existed are not now to be found. There is a quarry in highly hornblendic Laurentian on the property of Charles McKeone, south of the turnpike and about one-third of a mile south-west of Villa Nova station, and a rocky hill of Laurentian on the land of Miss Martha Brown, half a mile south of Radnor station on the banks of Harding's run.

South of the turnpike flows Ithan creek, first eastwardly then southwardly into Darby creek. Along this, on the property of Mr. P. C. Erben, about a mile south-south-west of Radnor station, 400 feet north of the old Lancaster road and 800 feet north-west of the Spring Mill road, a considerable exposure of Laurentian may be seen, with an interesting dyke of trap about six feet wide, dipping ± 30 nearly due north. North-west of this, along the stream are large masses of the rock and, after passing the road (0.9 miles south-west of Radnor station) a bold bluff occurs. The exposures on Ithan creek to the south-east, will be referred to hereafter.

South of these localities is the old Lancaster road. This road, at Rosemont, is but about 800 feet S. of the turnpike, but it bears more westwardly until it is half a mile

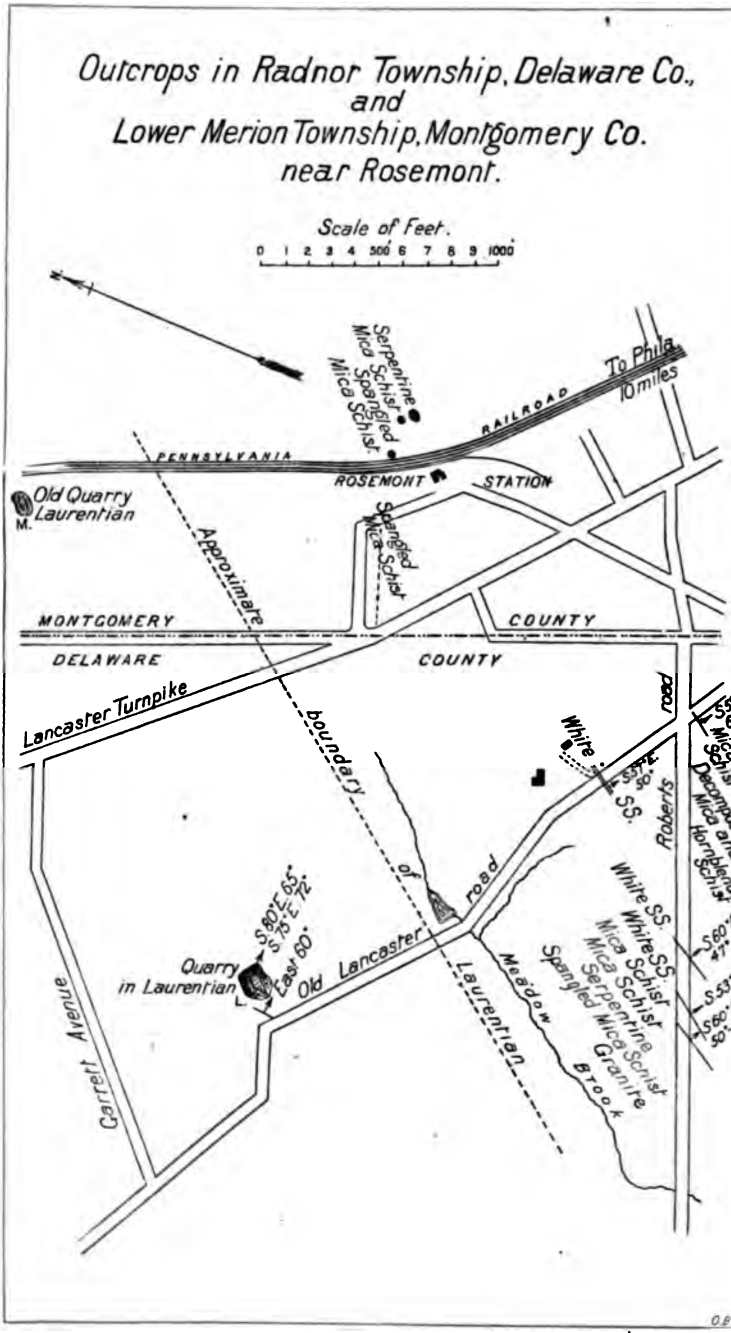
distant; it then approaches the turnpike again and unites with it 0.7 miles west of Wayne station, Pennsylvania railroad.

Along this road are many outcrops; one of the most important is a quarry on the land of Jos. F. Tobias, 1800 feet W. S. W. of Rosemont, (L. on plate, page 1578), whence a reddish feldspathic granite was quarried, out of which the rectory of the church of the Good Shepherd, on the Lancaster turnpike half a mile north-west of Rosemont, was built.

In the north part of this quarry dips S. 80 E. 65° and S. 75 E. 72° were obtained, and in the south part 60° nearly due east. South-west of this there is a quarry on the property of Dr. Edward Williams, another on the property of Jesse Gyger, east of the Roberts road, 1¼ miles south-west of Rosemont. Dip 45° south-easterly. Also, an exposure on the Roberts road just beyond Valley run, about a mile south-west of Rosemont, and on the same road a quarter of a mile beyond. There is a quarry on the Cooperstown road east of the Roberts road on property of John K. Valentine, showing a dip 45° south-east. West of these exposures and south of the old Lancaster road the Laurentian is exposed along the banks of Ithan creek, particularly the west bank and in its bed. The rocks rise steeply, in some places precipitously; along the summit (watershed between Ithan and Darby creeks) runs the Radnor and Chester road, along which the same rock may be seen in loose masses and occasionally in place (one large outcrop on farm of J. W. Worrall, north of the road), as far as the Roberts road, where it is succeeded by enstatite and serpentine.

Along the west bank of Ithan creek, on property of D. C. Abraham and David Paxson, the sequence of rocks going south-east is:

1. Laurentian, decomposed.	
2. Laurentian, heavy bedded	100′
3. Trap? dip S. 30°, E. 80°,	5′
4. Concealed,	50′
5. Trap,	25
6. Concealed,	40′
7. Laurentian with large garnets, rock quite garnetiferous, dip S. 30° E. ± from 5° at N. W. end to 0° at S. E. end,	50′
8. Trap? in long angular fragments,	30′
9. Laurentian, heavy bedded, dip S. 30° E. ± 40°,	100′


Outcrops in Radnor Township, Delaware Co., and Lower Merion Township, Montgomery Co. near Rosemont.
Scale of Feet.
0 1 2 3 4 500 6 7 8 9 1000
Serpentine
Mica Schist
Spangled Mica Schist
PENNSYLVANIA RAILROAD
To Phila. 10 miles
ROSEMONT STATION
Old Quarry Laurentian
M.
Spangled Mica Schist
Approximate boundary of Laurentian
MONTGOMERY COUNTY
DELAWARE COUNTY
Lancaster Turnpike
White
SS.
Roberts road
Old Lancaster road
Quarry in Laurentian
S 80° E 65°
S 75° E 72°
East 60°
Garrett Avenue
Meadow Brook
White SS.
White SS.
Mica Schist
Mica Schist
Serpentine
Spangled Mica Schist
Granite

In a quarry on the east side of the creek, south of the Roberts road, the dip is S. 45° E. 60°. On the east side of Ithan creek about 100 feet north of the Roberts road a dyke of trap is exposed in a quarry. South-west of this along Darby creek the exposures are almost continuous. The south-eastern border may be traced across Darby creek north-west of the bridge over which the road from Coopertown to Newtown Square passes (nearly a continuation of the Roberts road). There is a quarry in it within a hundred feet west of the road near the bridge. It crosses the road three or four hundred feet from the bridge. On Fawkes run, about 1½ miles from Darby creek towards Newtown Square (north), it is exposed in a cut for the Chester County railroad.

The north-west border of the Laurentian passes across Radnor township, crossing the county line road close to the Mattson's Ford road, a mile east of Radnor station, running thence nearly parallel to the latter road, and probably about 5° S. of W. crossing the Pennsylvania railroad and the Lancaster pike close to Wayne station. At the county line and eastward of it to the Schuylkill its slope northwestward is quite steep. It is well exposed in a quarry on the old Lancaster road, ½ mile south-west of Wayne, also along the back road to Eagle, south of the Lancaster turnpike.

About 1½ miles S. W. of Devon station (Easttown), it forms a conical hill of remarkable appearance, and here the belt appears to attain its greatest width, measuring nearly or quite four miles to the outcrops on the road from Coopertown to Newtown Square. Soon after passing this point the margin tends southwardly.

Along Darby creek are numerous exposures, but none of particular interest.

While we may not be absolutely sure that this belt is Laurentian there seems so little doubt of it, that I have so termed it. It seems certain that it is the oldest formation of the region, an anticlinical ridge against which rest the formations on the north-west and south-east. The dips on the south-east are quite uniform, on the north-west very obscure, but probably not far from vertical.

The rock of this belt has been much used in buildin Many small quarries have been opened, and large amoun of surface stone have been used in foundations and rou walls. It has not been used largely for face stone, owi to portions of it becoming rusty on exposure, and becau of its extreme hardness making it difficult to dress. S lected portions, however, make excellent face stone. E amples may be seen in the wall enclosing Dr. William property on the Roberts road ¾ mile south-west of Ros mont, also in two buildings on property of Thos. Wi iams, Jr., ½ mile west of Radnor station, and in the re dence of Mr. Morris, near Upton station.

The largest quarry is on the property of John M. Ke nedy, Jr., on the old Lancaster road close to Wayne av nue ½ mile south-west of Wayne.

This was opened for bridge and culvert stone, for t widening and straightening of the Pennsylvania railroa about 1880, and blocks with straight fracture and of ma tons weight were abundantly obtained.

Forming a prominent ridge north-west of this Laurenti hill are the hydromica schists of the South (Chester) Va ley hill, believed by Mr. Hall to be of Hudson River ag These have been frequently termed talcose schists a chlorite schists, but I have not met with either talc chlorite in them. I think them exclusively hydromi schists. These have been so well described, and are so u form over so large an extent of country that further d scription is unnecessary.

At Eagle station, south-east of and within 500 feet outcrops of this rock an artesian well was drilled. No le than 300′ of loose material was passed through before t solid rock was reached. This was quite unexpected, nearly everywhere in this region the undecomposed ro lies near the surface. The well was continued in the san rock 1400 feet further, but did not yield much water and now used for the supply of a private dwelling. This we is little if anything over 1000 feet from the line of serpenti outcrops, hence within 300 to 1000 feet of the edge of the h dromica, showing a steep dip, if the structure is synclina

From the well-defined Laurentian to the hydromica schists there is but a short geographical distance probably nowhere exceeding half a mile. This generally is a valley and to the northeast is a deep valley. In this narrow space we find a series of rocks, the relation of all of which to each other is not certain, the outcrops are few and poor. Nowhere are the rocks well exposed and no large quarries have been opened in them.

First upon the Laurentian is the rock described by Prof. Rogers and called by him "altered primal." His description of it is perfect, "metamorphosed with characteristic white streaks of imperfectly crystallized feldspar, and hard hornblendic material with roundish specks of semi-crystallized feldspar."* It is a gneiss much resembling some of the adjacent Laurentian, from which it was probably derived. It is characterized by thin layers of varying character, feldspar being abundant, mica, hornblende and quartz varying in the layers from almost nothing to great abundance, and many of these layers often appearing in an inch, giving at times a schistose character to the rock, but the mica and hornblende never so abundant that the rock can be properly termed a schist. Some of it is minutely, but excessively, contorted.

This rock forms part of the N. W. slope of the gneissic ridge, and is exposed in many places, while its fragments occur abundantly in the soil, from the Schuylkill to a point beyond the region under study. Its strike is parallel with the Laurentian ridge; its dip is nearly vertical, though good measurements are not to be had. East and north-west of Radnor station this rock is north-west of the Serpentine; near Paoli it is south-east of it. In terming this rock "altered primal" I am quoting Rogers and not asserting that it is really altered Potsdam. It seems quite distinct from the Laurentian.

North-west of this, at five localities, is a narrow outcrop of a rock identical with the eurite of Barren Hill. The rock is a friable feldspathic sandstone with rhomboidal partings, an easy cleavage in one direction, with micaceous

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* Geol. of Pa., Vol. 2, p. 72.

coatings on the surfaces of cleavage, the rock full of minute tourmalines.

The most eastern outcrop in Radnor township is on the west bank of Morgan's run, on the land of Brooke, in the north-east part of the township, very near the north-west corner of Lower Merion township, 400 feet S. of the Gulf Creek road, and 300 feet W. of the Delaware and Montgomery county line road.

The most western is in the cut of the Pennsylvania railroad about 1200 feet west of Wayne station (R.) and about two miles a little south of west of the locality first mentioned. At the east end of this cut may be seen the altered primal of Rogers for about 200 feet, then trap (the Conshohocken dyke), then altered primal, then the eurite dipping apparently 20°–25° toward the north-west, then obscure, then quartz fragments, characteristic of the hydromica schists. Between these it outcrops in the bed of Gulf creek, about three-quarters of a mile east of the last locality, the exposure is poor, but in place; it is characteristic and accompanied by a mica schist exactly resembling that found close to the white sandstone in the Roberts road S. W. of the old Lancaster road (R) on the S. E. side of the syenite.

The eurite occurs abundantly in loose masses on the surface for a half mile west of the first locality. These masses were much more compact and hard than those exposed in place, but, making excellent building stone have nearly all been removed. These outcrops are in precisely the same relative position to the Laurentian and the hydromica schists as those of the Potsdam east of the Schuylkill, and in West Marlborough township, Chester county, of which they appear undoubtedly to be a continuation. There are also outcrops in the same line north-eastward on both Montgomery avenue and the Gulf road, east of the Mattson's Ford road (L M).

In the cut at Wayne a number of well-formed columns of trap were found.

North-west of the line of the eurite is a very narrow belt of limestone, apparently a continuation of the wider out-

crops near the mouth of the same valley opposite Conshohocken, and of the still larger exposure N. E. of the Schuylkill. It contains crystals of pyrites and resembles the limestone of the south-eastern part of the Chester Valley on the N. W. of the South Valley hill, determined to be of Cambrian age.

In West Conshohocken there are two outcrops of this limestone, about two hundred feet apart, separated by mica schist, with mica schist S. E. of the S. E. one, the schist between them dipping S. 16 E. 74°. The limestone dips about 80° to the S. E., but at another exposure further S. E. 70° to 80° N. W. South-west of these the limestone is not visible for mile and a half. At the gulf, through which the Gulf creek passes through the hydromica schist ridge (U M), on the a south-east flank of the ridge, near and south-west of the Gulf flour mill, it appears with nearly vertical dip, on the south-east side of and almost in contact with the trap dyke. The outcrop is narrow and small, and not well exposed.

A mile west of this and 0.6 miles N. of Radnor station, on land of Brooke, formerly Stacker, is an outcrop in the bed of Gulf creek, where, previous to quarrying, a small waterfall existed over this limestone. It is about forty feet in width, the walls very compact slaty gneiss (?) on both sides. The strike of the limestone is about N. 65° E., the dip south-easterly but almost vertical. The westernmost outcrop is on the land of Peter Pechin, a few feet north of the Gulf creek, east of the Radnor and King of Prussia road and about 1,200 feet S. 76° W. of the last mentioned outcrop. It is very small. In the same general direction and at a very short distance north of a line joining the eurite outcrops are two sink-holes close together on a line S. 70° W., about a half mile due north of Wayne Presbyterian church. At the Brooke-Stacker quarry this limestone was many years ago burned for lime, recently it has been used for building purposes, the house of Mr. Geisse, one-half mile north-north-west of Radnor station, being built of it, but the deposit is so narrow and so near water-level, that the quarry cannot be wrought economically. This deposit is in line with the outcrops north-west of West

Chester, referred to hereafter. Adjacent to it and in the same linear position at least two localities west of it are deposits of limonite similar to those adjacent to the limestone north of the hydromica.

North-west of the limestone lies the Conshohocken trap dyke, well exposed at the west bank of the Schuylkill, where it is nearly a quarter of a mile from the limestone,* hydromica schists intervening. An excellent photograph of this outcrop by Mr. E. B. Harden will be seen in the heliotype plate.

It continues S. W. in an almost straight line nearly parallel to the edge of the hydromica schists, not often visible in place, but continually evidenced by abundant loose masses.

Close to the Schuylkill the hydromica schist hill is quite narrow, and the trap has been transported down both slopes to the valleys on the south-east and north-west, half a mile from the river, and thence westward it is solely on the south-eastern flank.

It crosses the Gulf road near the base of the hydromica hill, and is well exposed, with columnar structure, in the dam of the Gulf mills in which it is utilized as a base for the dam. It crosses the Montgomery-Delaware county line; also the Radnor and King of Prussia road close to, and north of Gulf creek; south-west of this it appears S. of the creek. The Pennsylvania railroad crosses it about 1000 feet west of Wayne station, where it is in or south-east of the "altered primal" and S. E. of the eurite, and it appears in approximatively the same line beyond the townships under consideration. So much stress is frequently laid upon the influence of dykes of trap in altering adjacent rocks that it may be interesting to note that in the passage of this dyke through the "altered primal" (Wayne R.); the limestone (Gulf Mills, L. M.);† the hydromica schists

*Directly across the river and perhaps less than half mile distant in the cut of the Schuylkill Valley railroad the trap dyke is within less than 100 feet of the limestone and south-east of it, with either decomposed hydromica schists or decomposed very schistose limestone between.

†South-east of the Gulf and not Gulf Mills P. O., which is at McFarland's Mills, on the north-west side.

HELIOTYPE PRINTING CO., BOSTON.

TRAP DYKE AT WEST CONSHOHOCKEN, LOOKING WEST.

FROM NEGATIVE BY E. B. HARDEN.

south-east of Rebel hill or Mechanicsville, ½ mile north-east of the Gulf mills; and in the cut of the Schuylkill Valley railroad at Conshohocken, not the slightest change, mechanical, chemical or physical due to the dyke is apparent. It has even been asserted that the serpentine is probably due to an alteration of the hydromica schists by this dyke. If so the energy of the dyke south-eastward must have passed through several hundred feet of rocks without affecting them to act upon the rock converted into serpentine while hydromica schist in contact on the north-west is unaltered.

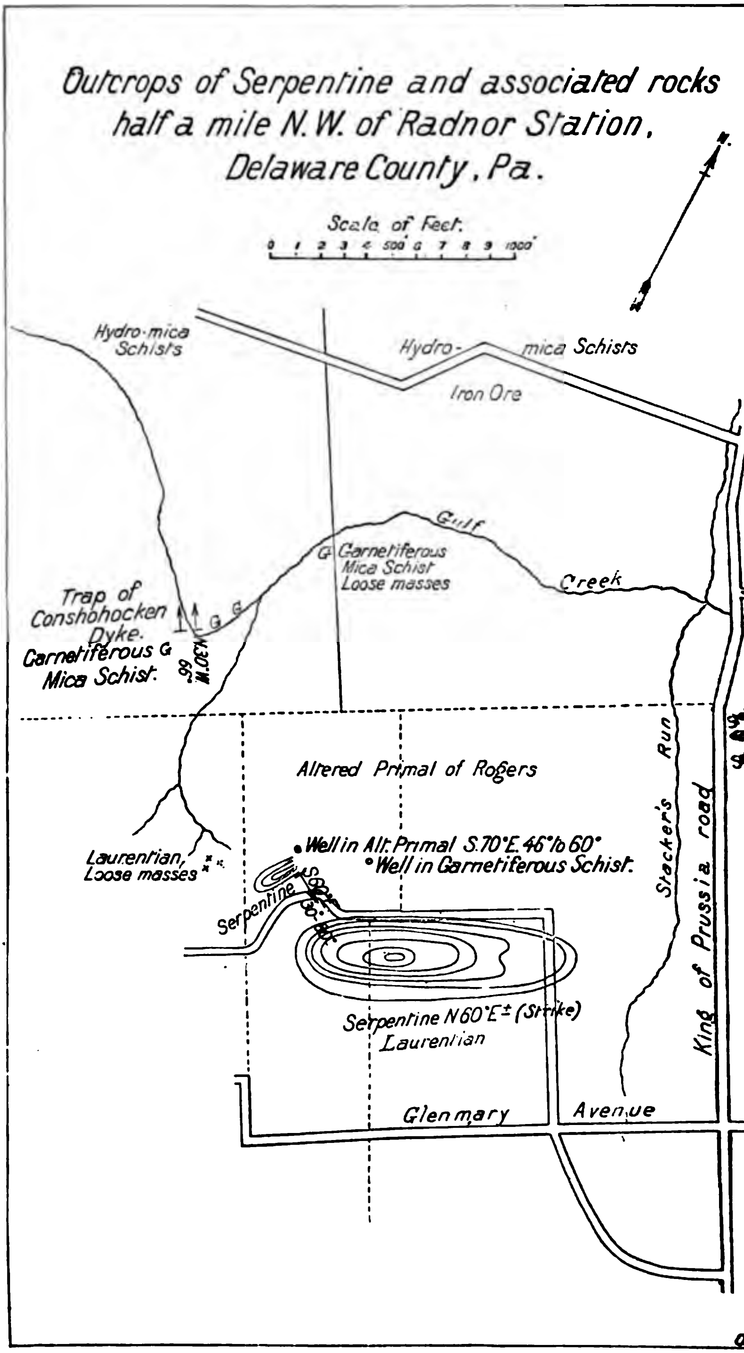
The sequence of the rocks described is certain, but there are others of which the position is uncertain.

1. Hornblendic rocks flanking the serpentine belt east of Radnor station on the north are probably Laurentian, certainly bounded by Laurentian rocks on the north. Hence the serpentine is wholly within the Laurentian at this point.

2. Two distinct Serpentine belts which will be considered more in detail hereafter. The southerly and most extensive and important one beginning, at its eastern end, on the property of Hon. D. J. Morrell, 6 miles east-north-east of Radnor station. It is composed almost entirely of a very dark green, almost black, serpentine, and is apparently in contact with the Laurentian on both sides, and is certainly on the south-east of the "altered primal" of Rogers.

The northerly belt is small in comparison, and contains much steatite. It shows outcrops east of Gulf road and in the same road south of the Mattson's Ford road; in and also north of the Mattson's Ford road, east of the Delaware-Montgomery county line road, and on the property of Judge Hare and of Lewis T. Brooke (R) It occurs also north-west of these roads, about 3000′ north-north-east of Radnor station, and about 1500′ north of the easterly end of the southern belt, and on the Radnor and King of Prussia road about 500′ S. of Gulf creek and again 4 miles from Radnor station.

3. Garnetiferous mica schists, almost certainly two distinct horizons, the southerly closely resembling the wood-like schists near the Soapstone quarry on the Schuylkill



Outcrops of Serpentine and associated rocks
half a mile N. W. of Radnor Station,
Delaware County, Pa.
Scale of Feet.
0 1 2 3 4 500 6 7 8 9 1000
Hydro-mica Schists
Hydro-mica Schists
Iron Ore
Gulf Creek
Garnetiferous Mica Schist Loose masses
Trap of Conshohocken Dyke.
Garnetiferous Mica Schist.
Altered Primal of Rogers
Laurentian, Loose masses
Well in Alt. Primal S. 70° E. 46° to 60°
Well in Garnetiferous Schist.
Serpentine
Serpentine N 60° E± (Strike)
Laurentian
Stacker's Run
King of Prussia road
Glenmary Avenue

at Lafayette and vicinity ; the northerly, harder, less wavy, forming large masses and containing large garnets, also staurolite. See plate p. 1586 .

The southerly exposed on the Mattson's Ford road, about 500′ E. of the Delaware county line (L. M.) are close to the steatite, and are also close to the steatite outcrop on the property of Judge Hare.

On the property of H. A. Geisse, ½ mile north-west of Radnor station and about 300 feet north of the southerly belt of serpentine (see plate p. 1586) a well was sunk and exposed this garnetiferous schist, with a steep southerly dip. Another well about 300 feet S. 85° W. ± from the last, or approximately 100 feet across the strike was sunk in decomposed "altered primal" dipping S. 20° E. 46° to 60°. North-west of this there is abundant evidence of the altered primal in addition to its exposure in two small quarries. About 1600 feet N. W. from Geisse's occur a number of masses of the harder mica schist, some of them containing many cubic yards. It is compact, not wood-like, the mica surfaces are smooth and brilliant, the garnets few in number and large, many well crystallized ; and occasionally staurolite occurs. These masses are along the Gulf creek and may not be in place, but the same rock occurs, undoubtedly in place, on the land of Frank Fenimore, about ⅜ of a mile a little north of west of Radnor station, near and south-west of the Gulf creek. Its exposure is not very satisfactory, but it appears to strike about N. 60 E. and to dip about 66° north-west. About ¾ of a mile nearly due west of the Fenimore locality were a number of loose but very large masses of the same rock on land of Childs & Drexel, formerly owned by L. Lewis. It occurs also in considerable quantity further west in Willistown and East Goshen, Chester county, also north of the serpentine north of West Chester and thence south-west it may be seen between the two outcrops of limestone on C. Cope's farm, 1⅛ miles N. W. of West Chester.

East of the Radnor outcrop it may be seen N. of the Mattson's Ford road ¼ of a mile E. of the county line (L. M.) on the property of the late Moro Phillips, south of the

Ford road, east of the Gulf road, west of the Merion fu
nace in West Conshohocken, where it lies between two ou
crops of limestone, an exact repetition of the outcr
north-west of West Chester, (though the schist here a
pears destitute of garnets). Also in the bed of Arrowmi
creek, where it is well exposed, some strata garnetiferou
some not so, and also along the road parallel to the Schu
kill north-east of Arrowmink creek.

On Arrowmink creek may be seen a bold outcrop of t
"altered primal," dipping S. 20° E. 85°, followed on t
northwest by the schists dipping S. 25° E. 80°.

On the last mentioned road going north-west the Laure
tian is crossed ending with a dip S. 30° E. 73°, then obscu
with a broken up sandy rock breaking into small angu
fragments, dipping to the south-west, followed by t
schists, here not very garnetiferous, but resembling t
spangled mica schist on the south west slope of the Laure
tian with dips S. 60° E. 86°.

At this point, as also north-west of West Chester, the
schists are visible for a width of at least 300′ and probab
extend much further.

The quarry exposures on Cope's farm, northwest of We
Chester, have several points of interest. To the S. E. of t
limestone lies a region of Laurentian. The south-east wall
the larger (southerly) quarry appears to be Laurentian, wi
interbedded limestone, reasonably supposed by Dr. Fra
to be not really Laurentian, but a more recent rock co
posed of fragments of the Laurentian. The dip varies, b
is to the south-east. Bounding the limestone on the nort
west is the garnetiferous schist conformable dipping S. 50°
55°, the contact is plainly visible. This schist continu
about 150 feet, when limestone again appears apparent
rising in an anticlinal overlaid by the schists.

About 500 feet N. 50° to 65° E. of the two limesto
quarries, is a narrow bed of steatite, or talc schist, abo
two feet wide, underlaid by Laurentian and overlaid by t
schists (not garnetiferous) the whole forming a small sync
nal.

Further east is the extensive serpentine belt north

West Chester; within 500′ to the south-east of it, is undoubted Laurentian dipping N. 35° W. 30°. The serpentine dips with considerable regularity about S. 45° E. ± 43° and to the north of it is the garnetiferous schist, in some places containing much staurolite.

In C^4, p. 66, the garnetiferous schists in Chester county, are stated to be altered hydromica schists.

"The slates along the southern edge of the belt are somewhat garnetiferous and at two places in Willistown and E. Goshen turn into a true garnetiferous schist."

In Radnor and Lower Merion this garnetiferous schist, which cannot be distinguished from that at the localities in Chester county, seems to be entirely distinct from the hydromicas, which everywhere preserve their distinctive character and there is no evidence of a change of one into the other.

In brief, we find north-west of the Laurentian, in Lower Merion and Radnor, a valley known locally as Cream valley, less than a half mile in width, bounded north-west by the hydromica schists of the South Valley hill, its bottom limestone with iron ores, with no visible stratified rocks between the limestone and the hydromica schists, except at Brooks quarry; but between it and the Laurentian occurs a variety of rocks, one of them probably Potsdam sandstone. A striking feature is the narrowness of these areas. Except close to the Schuylkill, the limestone does not appear to be over fifty feet in width, the eurite probably only a few feet, and the mica schists not visibly much more. There is no evidence of a fault. The limestone outcrops north-west of West Chester lie in the same relative position to the hydromica and the Laurentian, as does also the Potsdam in West Marlborough, and seem to be identical with those of Cream valley, as certainly are the limestone and Potsdam of Spring Mills, in the same line north-east of the Schuylkill. The drainage, like that of the Chester valley, does not follow the valley. The Gulf creek rising north of Wayne, flows down the valley to Gulf Mills, where it bends abruptly to the north and flows through a deep gorge in the hydromica schist ridge, thence along the northerly slope of the

ridge to the Schuylkill, resembling the passage of the V ley creek through the North Valley hill at Valley For A small creek rises north-east of the gulf and follows valley to the Schuylkill.

In this valley the iron ores (limonite) which occur, h been mined at three places at least; one, the most ext sive, about a mile from the Schuylkill (L M), one, on farm of Peter Pechin, three-quarters of a mile N. W. Radnor station (R), and the third west of the road from David's church to Valley Forge, on the line between Delaw and Chester counties, about a quarter of a mile S. of Pennsylvania railroad, now included in the Devon property.

None of these mines have been wrought for some yea

Iron ore fragments occur at the crossing of the Eagle r over the Pennsylvania railroad west of wayne, and ab two hundred yards north-west of the eurite outcrop, in same general line with the deposits mined.

If Mr. Hall's conclusions are correct, and the hydrom schists are of Hudson river age and overlie the Ches county limestone, then the limestone and eurite of Cre valley are the limestone of the Chester valley and the P dam of the North Valley hill rising on the south-easte leg of the synclinal. The extreme thinness might be plained by a deposition in shallow waters on the shores the Laurentian highland. This hypothesis seems best agree with the exposures in Cream valley.

It seems unquestioned that E. of the Schuylkill, going W. from the Laurentian syenite, Potsdam sandstone is with close to the river, (C[4], p. 110*), then limestone a then hydromica schist; and also that in E. Marlborou Chester county, about twenty-four miles S. W., the syen and hydromica being continuous for the whole distan there is precisely the same sequence of rocks, though th may be, in the latter section, rocks between the Laurent and the Potsdam.

* In C[4] these outcrops are referred to the *North* Valley hill, but t border the Laurentian on the north-west and are *between* it and the li stone as clearly shown on the map in C[4]. Beyond the limestone is hydromica of the South Valley hill, then the limestones of the Chester ley, and beyond them the Potsdam of the North Valley hill.

Between these two extremes good exposures are rare, hence, if at intervals the Potsdam and the limestone *are* found is not the conclusion irresistable that the formations are practically continuous, and that whatever is the structure east of the Schuylkill, is that west of it? The only difference being that the hydromica schists are very largely developed, the Potsdam and limestone very thin.

It must be admitted that this theory does not explain the sandstone on and west of Samuel Tyson's, near King of Prussia (U. M.). On this farm, close to and west of the Radnor and King-of-Prussia road, a small stream flows northward through the hydromica schists into the Chester valley. The banks of this stream, at the foot of the (hydromica schist South valley) hill, are lined with masses of sandstone, some of tons weight, evidently transported from an outcrop clearly traceable along the hill near its base, accompanied by a ferrugenious sandstone, or conglomerate, passing into an iron ore, of which a considerable quantity has been mined. To the eastward of the stream hydromica schists appear, but not a trace of the sandstone. Further westward traces of it may be found for at least a mile, beyond which I have not traced it; but Rogers mentions it as occurring along the valley to the west, and he regarded it as Potsdam, the continuation of the North Valley hill rock under the Chester valley. Were this the structure, we ought to find in Cream valley, the Potsdam between the hydromica and the limestone, and not as it really occurs, only between the limestone and the Laurentian.

Rocks south-east of the Laurentian.

Between the Laurentian and the Delaware river is a wide expanse of gneisses and mica schists, divided by Rogers into his first and second belts, and by Mr. Hall into three, his intermediate or Manayunk belt comprising the northwesterly part of Rogers' first and the south-easterly part of his second. The remainder of Rogers' second has been conveniently termed by Mr. Hall the Chestnut hill garnettiferous schist group characterized by "silvery micaceous garnetiferous schists, bright-colored, thin bedded sandy

gneiss, the rock breaking into long narrow chunks con paratively smooth on their sides, but excessively ragged c their ends, a style of fracture strongly resembling that half-rotted fibrous wood." In this occurs the steatite bel and in it or north-west of it the Lafayette serpentine bel These will be considered hereafter.

Mr. Hall's intermediate belt is described by him as co taining alternations of gray schistose gneiss, and a predom nance of sandy gneiss, also mica schists and hornblend slate alternate with finer grained gneisses.

Rogers' first belt comprises gray schistose gneiss con posed of quartz, feldspar, black or brown mica and occ sionally garnets, occasional beds of black hornblendic sla and fine-grained sandy gneiss.

Sub-divisions of these belts may be easily traced ov considerable distances, and there seem to be some rocks n fairly included in these descriptions. Going south-eas ward from the Laurentian we find:

1. A rock which I have termed *Spangled mica schis* This is sometimes a gneiss; its characteristic feature bein that part of the mica appears to be in small separate curve imperfect crystals, of which the surfaces, or the cleavage su faces, remain brilliant on exposure. These mica crystals (resemble the crystals of feldspar in a porphyry, and at or locality, S. W. of and near Darby creek, the rock is di tinctly porphyritic. This rock, while probably less than hundred feet in width in most places, is abundant and pe sistent from the Schuylkill to beyond Darby creek. It li immediately north-west of the Lafayette serpentine belt. have not found it anywhere on the south-east, the schis there being fine-grained mica schists, often garnetiferous.

This spangled mica schist may be observed in loose fra ments almost continuously, but outcrops in place are n abundant nor are they distinct. It may be seen at Ros mont on the road parallel with the Pennsylvani railroad, close to and south of the railroad; on the roa bearing north from the Roberts road; east of the Gulf roa and on the Roberts road, about ¼ of a mile south west of Rosemont station. There was an outcrop

the Lafayette serpentine about 500 feet north-east of Rosemont station, a small quarry, filled up and built over in 1885. In a well close to it, and north-west of the serpentine this rock was found. It bounds the same serpentine on the property of Col. J. F. Tobias, on the Roberts road, 1700 feet (along the road) S. W. of the old Lancaster road, and here seems to form quite a hill with some included granite, which has a strike N. 20° 25° 30° 32° E.; the only dip observed was S. 58° E. 80°. In the Roberts road the serpentine rocks are exposed, with the spangled mica schist on the north-west, dipping steeply to the S. E., while the garnetiferous mica schist on the S. E. of the serpentine dips about 60° north-west. If these dips can be depended upon they are evidence that here the serpentine lies in a narrow synclinal trough, but the exposures are not satisfactory. A loose mass of garnetiferous mica schist found S. E. of the steatite contained crystals of staurolite.

A remarkable occurrence of this spangled mica schist is upon Bryn Mawr avenue, between the Radnor and Chester road and Darby creek. Bryn Mawr avenue, south-west of the Radnor and Chester road, bears S. 65° W. and is in enstatite, which, with serpentine and allied rocks derived from it, occupies the ground about 400 feet reaching nearly to the Roberts road, and quite to it at the westerly end. Near its south-west end Bryn Mawr avenue bears more westwardly, and here post-holes showed the spangled mica schist with enstatite on both sides of it. Unfortunately the exposure is very poor.

On the road from Bryn Mawr and Coopertown to Newtown Square, south-west of Darby creek, and immediately north-west of the serpentine outcrop on Moro Phillips' property, the spangled mica schist is exposed, together with porphyritic gneiss, with a strike N. 65° to 70° E. and a steep dip to south-east. North-west of this point, strata of hard schists strike N. 50° E. ± followed by abundant Laurentian fragments. About 150 feet north-west from the spangled mica schist is a small quarry in hornblendic Laurentian gneiss, strike N. 62° E., dip probably south-east but uncertain. The rock is very massive and heavy bedded.

I have observed no other rock in place and persistent be
tween the Laurentian and the serpentine, but in places a
on the Schuylkill and about two miles west of it, fragment
of a rock closely resembling the "altered primal" occu
Masses of it are built into the wall of Dr. Williams' propert
on the Roberts road (R.) about a mile south-west of Ros
mont, derived, as I am informed, from loose surface masse
I could not find it in place. This is close to the spangle
mica schist, south-east of the Laurentian, and three mile
at least, from any outcrop on the north-west side.

South-east of the serpentine, mica schists, often garnet
ferous, often wood-like, containing some hornblende schis
and beds of white quartz, extend for about half a mile t
the steatite belt, and beyond about two miles, but in th
north-west edge of these schists, close to the Serpentin
occurs a rock that may possibly be Potsdam sandston
These mica schists are well exposed in the cut of the Rea
ing railroad, on the Schuylkill between the Lafayette se
pentine and the steatite, (L. M.) where they dip steeply t
the N. W.; also on the Roberts road north-east of th
Pennsylvania railroad, and also on the Gulf road east o
the Roberts road (L. M.) On the Gulf road close to th
Roberts road, hence 300 to 400 feet south-east of the lin
of strike of the serpentine, their dip is S. 45° E. 62°, at
of a mile south-east of the road, just W. of Taylor colleg
S. 48° E. 50° and $\frac{1}{4}$ of a mile beyond S. 57 E. 57°.

On the old Lancaster road 50 feet east of the Roberts roa
they dip S. 58° E. 65°; in the cut of the Pennsylvania rai
road, at Bryn Mawr, S. 25° E. ± 70°, and on Bryn Maw
avenue, south-east of the above, the strike is N. 33° E
nearly vertical.

In this part of the belt the schists are not contorted, bu
quite smooth and regular in their bedding; there are als
beds of hornblende schists. They are not so garnetiferou
as those further east, they are more quartzose and less dis
tinctly micaceous and contain beds of quartz, masses o
which are abundant in the fields. They closely resembl
schists, adjacent to the Potsdam north-east of Wayne
above mentioned.

The sandstone is best seen in the old Lancaster road, 500′ north-west of the Roberts road and in the latter ⅛ of a mile south-west of the Lancaster road.

In the old Lancaster road it dips S. 57° E. 50° and S. 52° E. 50° and on the Roberts road S. 60° E. 47°, the mica schist south-west of it S. 60° E. 50° to 52°. The rock is a friable feldspathic sandstone, very closely resembling the eurite of Barren Hill, but the characteristic tourmalines are not visible. It is in nearly the same position, I believe, in which Prof. H. C. Lewis found itacolumite, east of the Schuylkill, and in which undoubted Potsdam occurs further to the north-east. The same rock is exposed upon a road at right angles to the State road near the house of Wm. Shallel (L. M.), 1½ miles north-north-east of Bryn Mawr and south-east of, and near the serpentine, close to, and south-west of, the corner of the Gulf road and the Roberts road (L. M.). It is to be hoped better exposures of this rock may be found.

On the south-east of and near the serpentine may be found in many places loose fragments of a very hard syenitic gneiss, its surfaces smooth and parallel, and studded with small crystals of hornblende. It has been found near the Schuylkill; also about a mile west of it; near Bryn Mawr, and on the Radnor and Chester road, near Darby creek. Its only outcrop in place, to my knowledge, is in the Roberts road at the crossing of the old Lancaster road, where it appears as a stratum about 2½ inches wide in the soft mica schists. If this is its extent, in width, it is remarkable that it should be so uniform over so great a lineal distance. Its strike is N. 35° E. nearly vertical.

In the mica schists, and chiefly within one or two hundred yards of the serpentine are hornblende schists. They may be observed on the Gulf road south of the Roberts road, and at Bryn Mawr; much decomposed, on the old Lancaster road south-east of the Roberts road, and in a quarry just south of the serpentine on the north side of the Philadelphia and West Chester road (Newtown). At this place the hornblende is apparently changing into serpentine.

The garnetiferous mica schists appear to bound the stea-

tite belt on both sides, though at the old soapstone quar on the Schuylkill (Philadelphia), the south-east wall hornblende and actinolite apparently passing into chlor

In these mica schist rocks there seems to be a strat characterized by staurolite. Though the exposures not constant, they are approximately in line. It may seen at Magarge's mills, Wissahickon, Fairmount Pa Philadelphia, on the Old Lancaster road near the road le ing to Wynnewood station and in the latter road. A about a half mile south-west of Wynnewood, (H. L. M.) and near Darby creek in cuts for the Chester Cou railroad near Church Lane (H).

Unlike the Laurentian, and the porphyritic gneiss n described, these rocks do not widen south-westward fr the Schuylkill, but apparently become somewhat narrow being about 6 miles wide at the Schuylkill and about 5 mi at Darby creek.

These mica schists are bounded on the south-east and se rated from the Fairmount gneiss and overlying mica schi by a prominent and extensive belt of porphyritic gnei This, except the Laurentian, is the most uniform and ch acteristic rock of the region. This is within the area of I Hall's intermediate belt, or Manayunk mica schists a gneisses, but it is so very well defined, and so distinct in character and boundaries as to entitle it to be conside separately; the rock of which it is composed is hard within the descriptions heretofore referred to. It is a ve hard, compact, heavy-bedded gneiss, usually gray in col sometimes nearly black, and is generally porphyritic. contains much feldspar and little mica. Owing to its ha ness, it forms throughout most of its course, a well defin ridge, or table land. Its outcrops are almost continuo The imbedded feldspar crystals (twins) are sometim minute, when the gneiss resembles the Fairmount gnei sometimes two or three inches across. Its dip is most obscure.

There are two principal varieties.

1st, and most abundant, a fine grained gneiss of a gre ish color containing numerous twin crystals of orthocla

distributed uniformly through the mass, from very small up to two inches in diameter.

2d, a similar gneiss containing much less mica and very few or no feldspar crystals, forming a homogeneous rock, sometimes almost a felsite, with conchoidal fracture and very hard. The mica is sometimes replaced by hornblende in which case the rock, especially when the feldspar crystals are not numerous, bears strong resemblance to a trap, which resemblance is aided by the weathering into rounded masses lying upon the surface of the ground.

On its north-western border are hornblendic gneisses and coarse granites.

North-eastward it appears on the Schuylkill as a narrow belt at the Falls, Twenty-eighth ward, Philadelphia, at which point its outcrop in the river caused rapids, giving the village its name. This was the head of tidewater before the erection of the Fairmount dam. These rocks are now covered almost entirely by the back water from Fairmount dam, and part of them have been removed to improve navigation. The fine stone arched bridge of the Reading railroad over the Schuylkill is built of it.

There is a remarkable quarry, either in this belt or immediately north-west of it, on the west bank of the Schuylkill. The rock is a gneiss, but the proportion of the respective ingredients vary in the most remarkable manner and give rise to a greater variety of rocks than in any other quarry of the region. Quartz crystals, with interesting modifications, krokidolite and epidote, and it is said rhodonite have been obtained here, and upon one occasion in it was seen a natural *ink* formed by the wash or sap from trees above flowing over decomposing pyritous rocks.

The width here across the strike is probably but two or three hundred feet, but the belt widens rapidly, and within about two miles, at the Pennsylvania railroad cut, it extends from the crossing of the Lancaster pike ½ mile E. of Overbrook to Elm station, measuring across the strike at least a mile and a half. South-westward it probably still increases in width, and in this resembling the Laurentian.

This belt is well exposed at the Schuylkill, but its struc-

ture is not clear. On the N. E. bank the dips are norther from 45° on the north-west to 15° more south-east; on t S. W. bank they dip 70° north-west becoming steeper the south-east, then vertical, then again north-west.

A section on the line of the Pennsylvania railroad, sho a distinct anticlinal, at the extreme N. W. outcrop in quarry, about 1500 feet south-east of Wynnewood, with di from S. 50° E. 20° to N. 50° W. 20°. In the cut of the Pen sylvania railroad, beginning about a half mile east of th quarry, the westernmost dips appear to be south-east, so strata nearly horizontal, apparently a succession of fold with no dips steeper than 30° and much false stratificatio due to decomposition. Below Merion station, the strike N. 35° E. and N. 45° E. dip obscure, probably nearly horizo tal. Below Overbrook, there is decomposed gneiss, (pos bly a gneiss overlying the porphyretic) dip ± 45° N. W., b coming steeper to the south-east, followed by heavy-bedd porphyretic gneiss and then mica schist dipping 70°± to t south-east, the dips becoming steeper south-eastwardly.

South-west of this the cutting of Landsdowne aven through this rock gives a good exposure. The gneiss very massive and the structure obscure, but apparently the south-eastern part the dip is to the south-west, in t middle vertical, and at the western part 5° to 15° south-eas then 5° to 10° north-west. There are coarse granitic vein or strata, probably veins. The western end of the Lan downe cut is not west of the middle of the belt.

This rock is deeply cut by Darby creek and its affluent Cobb's creek and Indian creek.

On the latter the rock is well exposed at a mill abo half a mile north-west of Haddington, where there is a near vertical cliff of some eighty feet in height. Near by, a ve dense, compact, hard variety of the gneiss was quarri and also a highly feldspathic, almost white and compar tively soft variety; while further up the creek and near t line between Philadelphia and Delaware counties, a da hornblendic, hard and heavy variety occurs in loose tra like masses.

Cobb's creek cuts this belt, forming a valley of consider

ble depth with banks mostly steep and occasionally precipitous. The creek descends probably 100 feet or more in three miles.

A section along the creek from Sixty-third and Market streets, Philadelphia, westward and north-westward shows as follows:

In a quarry south-east of Sixty-third and Market a very compact gneiss, not porphyritic but evidently of this belt, S. 70° E. 76° and S. 60° E. 60°.

About ½ of a mile north-west of this is a quarry in which the gneiss is perhaps better exposed than in any other, the rock is very regular, compact, in parts highly porphyritic, and in parts not so, and wholly unaltered. Here a satisfactory measurement S. 70° E. 85° was obtained; there are many minor contortions in the rock not affecting the general dip.

There is another quarry on the creek about ½ of a mile above the State road. The rock is excessively jointed, the joints rusty and weathered, but the weathering merely superficial; the rock very compact and hard. It has been largely quarried for road metal, for which it seems well adapted.

Along the creek above this are numerous loose masses, and near the city line, a highly hornblendic variety looking much like trap.

It may be noted that the granitic veins or beds in this belt are composed chiefly of feldspar, mostly, I think, orthoclase, with but little mica and quartz. It sometimes contains tourmaline, very rarely garnet; in the north-east part of the belt the granite is rare, but along Cobb's creek abundant. On Kelly's lane, a road half a mile north-west of the road dividing Philadelphia from Delaware county, and near the creek, coarse granite occurs, underlaid by a schistose gneiss dipping N. 40° W. 15° and N. 50° W. 59°.

About eight-tenths of a mile above the line between Philadelphia and Delaware county there is a bold hill of this granite. Just north-west of the granite a hard schistose variety of the gneiss, in bold bluffs, narrows the valley to a gorge; this rock is not porphyritic, in part it is almost

scythestone, and contains a few garnets. The dip is regular, but is probably about 30° N. 70° W. ±. A sim dip continues up the stream for 100′, where there is a s bed of the characteristic granite containing tourmal while within two or three feet in the line of dip the gn or schist contains garnet, kyanite and staurolite. 150 further up there is a bluff, distinctly porphyritic, bey which is a small double valley, the intermediate hil which is the granite of this belt in loose masses but in g quantity.

Just below the crossing of the creek by the road remarkable outcrop of a schistose gneiss containing garn similar to that above-mentioned. Seen in winter, when bare trees and shrubs permit an extended view and fro little distance looking, north-west, it would be taken f trap dyke. It rises with almost vertical walls from 10′ to The north-west slope is comparatively gentle. Obse closely it is seen to be a schistose gneiss containing a large garnets. It is in masses of many tons weight, som them disrupted as if by a recent earthquake. Just bey this the same granite appears, and further up the cha teristic gneiss of great hardness, well exposed in a qu on the north side of the creek ⅛ of a mile east of the Ha ford road and in the bed of the creek below the dam. satisfactory measurement at the wall-like exposure gave N. 40° W. In the quarry the dip is nearly vertical contortions; the rock very compact and not distinctly phyritic. West of this the soft garnetiferous Bryn M schists appear and are exposed on the road crossing the cr near St. Denis Church dipping north-west 45° ±. No east of the creek on the same road they dip 45° ± N. 20°

The interesting feature here is finding, clearly wi this hard gneiss, strata of schists containing garnets, s rolite and kyanite, not very unlike those occurring to north-west on the Schuylkill and Wissahickon, but tirely unlike the Manayunk garnetiferous schists, and question arises whether they are, as they seem to be, re interbedded or whether they are overlying strata caugh sharp synclinal over-turned folds.

On the line of the (proposed) Chester county railroad, going westward from Angora station, we find mica and hornblende schists slightly exposed. The mica schist, or schistose gneiss, dips S. 40° E. 30° beneath gravel and is followed by the hornblende schists nearly vertical. After crossing Cobb's creek there is a cut through the porphyritic gneiss. At the east end of this cut the dips are N. W.; at the middle nearly horizontal, then slightly N. W. and curved. In the next cut, at the east end, the rock dips about 65° N. W., succeeded by nearly horizontal strata the dips then becoming north-west and steep. At this point there is a large bed of quartz, in part crystallized like the so-called "Babel quartz"; this is close to the Marshall road; beyond it the gneiss dips N. 40° E. 55°, much decomposed. Beyond the Garrett road there is micaceous gneiss, followed by a hard compact granite, dipping N. 20° E. 30°, and north-east of the State road (two miles from Cobb's creek) a nearly white granite, weathering red, with compact and schistose gneiss dipping N. 55° W., composed of numerous layers of different colors.

North-west of the State road the porphyritic gneiss occurs in very compact masses containing much black mica, making a rock easily to be mistaken for a hornblendic gneiss, or even trap. This continues for about a mile and is succeeded by micaceous schists containing staurolite and kyanite. No dips could be obtained in the western part. Whether the granites and gneiss between the Garrett road and the State road belong to the porphyritic belt, or underlie it, is uncertain.

This gneiss continues to and beyond Darby creek, but to what distance I have not been able to ascertain.

South-east of the porphyritic gneiss belt are mica schists and hornblende schists, well exposed along the Schuylkill, and in many small quarries, underlaid by the Fairmount gneiss, properly so-called. This gneiss, upon the hill on which the Fairmount basins are placed, is a fine-grained orthoclase-albite-muscovite gneiss. It makes an excellent building stone. At Fairmount, where, on the west bank of the river, it has been extensively quarried, its laminæ are

contorted, but near Chester they are more regular, so t curbstones twenty feet or more in length are obtained.

This gneiss differs from all others of the vicinity in c taining numerous veins, or beds, of granite, generally v coarse, apparently segregated, the feldspar and mica o well crystallized.

At times, however, the granite appears to fill fissu with a displacing of the adjacent stratified rock.

A remarkable instance of this was exposed when Junction railroad was built. A short distance north of Pennsylvania railroad there was a cut through alterna strata of hornblende and mica schist. Two nearly vert dykes of granite penetrated these, but the displacem was very small. See plate p. 1570. It is no longer visi

In these veins occur several mineral species not fo elsewhere in the neighborhood. Opposite Fairmount, sides crystallized orthoclase, albite and muscovite, gar beryl, tourmaline, Autunite (lime-uranite), Torber (copper-uranite), bismuthinite (sulphide of bismuth), h been found.

In the vicinity of Chester, chiefly on the banks of Cr and Ridley creeks, it has been quarried very extensive all the above minerals except the bismuthinite have b found and in addition bismutite (carbonate of bismu pitchblende, uranochre, thulite and siderite.

The orthoclase, albite, beryl, tourmaline, garnet autunnite are found in this belt in very fine cabinet sp mens. The autunite and torbernite are found in the gn as well as in the granite.

The mica schists and hornblende schists, between and the porphyritic gneiss, seem to overlie the Fairmo gneiss. From exposures on the Pennsylvania railroad on the Chester County railroad they seem also to ove it. Some of the finer-grained portions of the porphyr belt bear a closer resemblance to the Fairmount gneiss t to any other rock near, and a resemblance may be tra between the mica schists and hornblende schists on e side of the porphyritic gneiss.

It seems probable that the latter occupies the crest o

anticlinal. The very massive hornblendic rocks so largely exposed on the Schuylkill, above the Columbia bridge, do not appear on the Pennsylvania railroad. The line of strike would cross the railroad somewhere in the vicinity of Fifty-second street. The elevation of the railroad being about 150′ above the river, it seems probable that these are lower rocks which are overlaid by mica schists on the higher ground.

About half a mile west of Fifty-second street, a peculiar gneiss (?) appears and was quarried for ballast for the railroad many years ago. Where undecomposed, it appears to be a felsite, full of iron pyrites, but most of it decomposes with great rapidity. A large pile of quarried stone intended for ballast, decomposed so completely in about five years that the masses which had not fallen to pieces could be crushed in the hand. In this quarry, halotrichite, the so-called iron alum, a sulphate of alumina and protoxide of iron, is a constant product of the decomposition. The same mineral occurs on the hornblendic gneiss, half a mile above the Columbia bridge, but there is no resemblance between the rocks.

At the Pennsylvania railroad this pyritous gneiss appears to occupy a synclinal, the axis of which rises at an angle of about 30° south-west either between the mica schists on the south-east of the porphyritic gneiss, and the latter; or perhaps in, but very close to the north-west border of the schists. It is between 200′ and 300′ in breadth.

In this connection may be mentioned another instance of the rapid weathering of a rock, due however, to the kaolinizing of an albite and not to pyrites.

This was in the Fairmount gneiss, where it was cut by the Pennsylvania railroad, north of Spring Garden street. Originally the cut was narrow, with nearly vertical walls. By the widening of the road-bed, the eastern side of this cut has been removed; the western remains, but has been reduced to a comparatively gentle slope.

In the southern part of this cut, within ten years, albetic gneiss that was so hard that it had to be drilled and blasted,

became so soft that a stick could be thrust into it to a depth of several inches.

Orthoclase and albite crystals and beryl occurred here. The orthoclase was hard and glassy, the albite often soft and chalk-like, and the beryl sometimes decomposed and softer than chalk.

A remarkable belt of gneiss outcrops in Frankford, Phila., with probably an anticlinal structure, but nearly horizontal. Precisely the same rock appears at Wayne station, Germantown (Philadelphia) and at McKinney's quarry on the Wissahickon at the bend about 1¼ miles from its mouth. If this rock is the same, and it can hardly be doubted, the rock must underlie the mica schists, and be raised by an anticlinal at a very different angle from the strike of all the other rocks of the region. A line about W. 4° N. would connect these outcrops. This belt also is characterized by its minerals; sphene, apatite, copper pyrites and other ores of copper, molybdenite in fine crystals, molybdic ochre, stilbite, heulandite, apophyllite, hyalite colored by uranium, Randite, sunstone, epidote, calcite, orthoclase, crystalized quartz, tourmaline and biotite, have been found at Frankford, nearly all in good, and some in fine specimens; several of them have been found at each of the other localities. One crystal of molybdenite measured 2X3 inches and weighed over a pound.

It may be but a coincidence, but it is at least noteworthy, that the strike of the tongues of Potsdam sandstone projecting into the limestone in Whitemarsh township, Montgomery county, shown on the map in C⁶, are almost identical in strike with this gneiss.

Gravel and Clay.

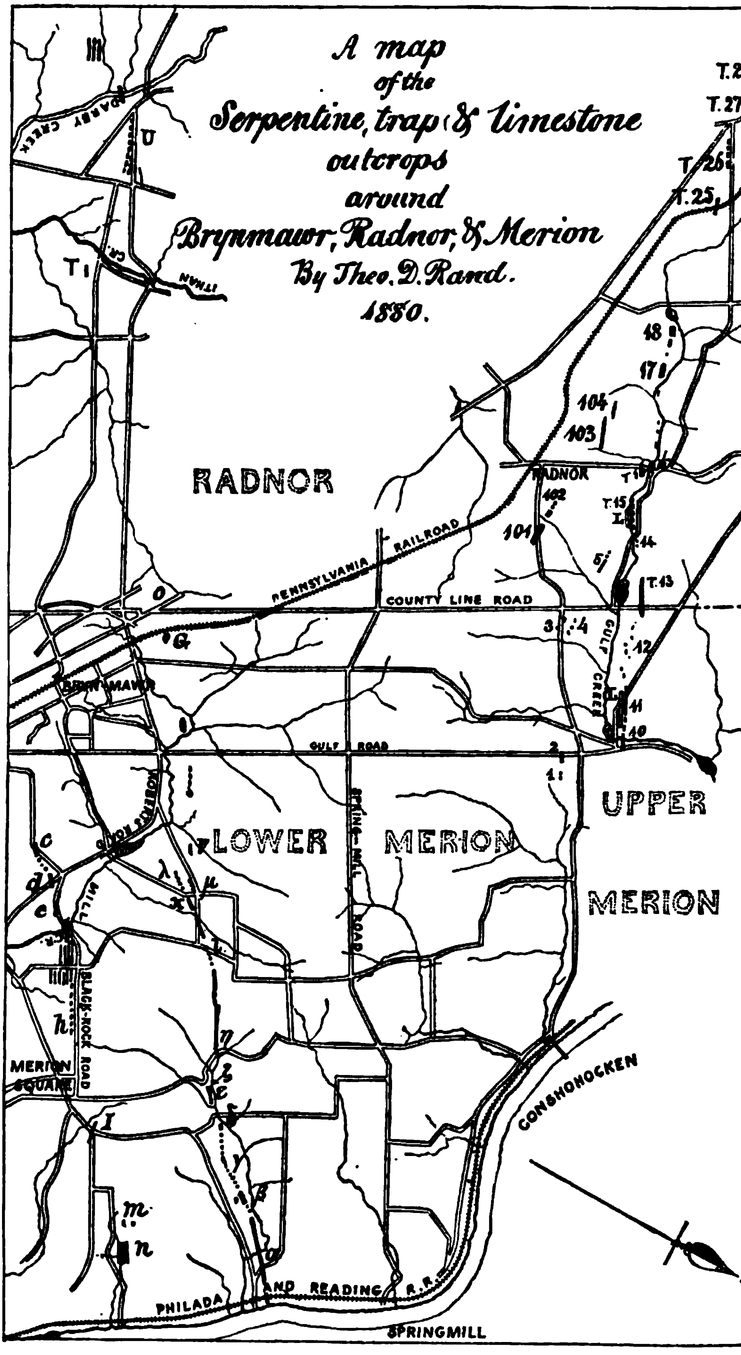
The Bryn Mawr gravel has been so well described that I can add very little to what has been published. There is one large outcrop not on the map in C⁶ which deserves notice as being probably the most eastern exposure near Philadelphia. It lies upon a high summit of the porphyritic gneiss hill near the northerly corner of Upper Darby township and is well exposed along the road from Phila-

delphia to West Chester, about two miles west of the bridge over Cobb's creek.

A deposit of clay, used for the manufacture of bricks, lies about a quarter of a mile north of Garrettville and about 800′ S. W. of the Lancaster turnpike at the Church of the Good Shepherd, west of Rosemont, and near the east line of Radnor township.

Under the surface soil there is three feet of a yellow clay of good quality, free from stones ; under this a stratum of blue clay containing much quartz, and under this, the common decomposed Laurentian. In a pit dug into this decomposed rock, for building sand, the quartz fragments are entirely unlike those of the clay and resemble those of the Laurentian elsewhere ; in the clay one rolled pebble was found, the other quartz fragments were sharp and not waterworn. Rarely they contained masses of decomposing feldspar. Most of them are milkwhite ; some very closely resemble -the hornstone found on the south-east border of the hydromica schists.

It seems not improbable that this is a remnant of an overlying feldspathic gneiss ; it is true that a sluggish stream draining the decomposing Laurentian into a lake or pond would account for the yellow clay, but the quartz fragments seem to be foreign to that formation in this region.


A map
of the
Serpentine, trap & limestone
outcrops
around
Brynmawr, Radnor, & Merion
By Theo. D. Rand.
1880.
RADNOR
PENNSYLVANIA RAILROAD
COUNTY LINE ROAD
GULF ROAD
GULF CREEK
LOWER MERION
UPPER MERION
SPRING MILL ROAD
MILL CR.
BLACK-ROCK ROAD
MERION SQUARE
CONSHOHOCKEN
PHILADA AND READING R.R.
SPRINGMILL
DARBY CREEK

Serpentine and Steatite.

The Steatite Belt in Lower Merion township, Montgomery County.

Going westward from the steatite quarry on the hill west of the Schuylkill (*n*), the steatite is visible about 300 feet west of the quarry (*m*), the next outcrop is at a road crossing (*I*).

At both the quarry, and at the road, the north bounding rock is distinctly the *woodlike garnetiferous mica schist.*

The course from *n* to *I* is about S. 45° W.; that of the road, S. 60° W.; and the strike of the steatite at *I* is apparently S. 60° W.

There was formerly an outcrop at Merion Square, but I am unable to find it now.

Between *I* and *h* the ground is low. At *h* a peculiar ferruginous quartz, probably *pseudomorphous after serpentine*, is visible in the road, and westwardly becomes exceedingly abundant over a considerable area, accompanied, further west, by the "bastard soapstone," or serpentine, *pseudomorphous, probably, after staurolite*, characteristic of this belt, and giving the road its name "Black Rock" road. Here the belt is nearly a quarter of a mile in breadth.

In this vicinity cavities are to be seen, with the form of *staurolite;* the serpentine having weathered away; the steatite remaining, reversing the order of decomposition in other parts of the belt, where, both weathering together, but the steatite most rapidly, the serpentine pseudomorphs stand out as irregular knobs.

The direction of this road along most of its eastward portion, is S. 60° W. Its course across Mill creek, and through these rocks in their greatest exposure, is winding; but a line from end to end of the winding part, has the direction of S. 40° W. The course of the rocks themselves is approximately S. 45° to 50° W.

At the end of the "Black Rocks" the road runs S. 45° W. for about 500 feet, and steatite appears in place in the gutter of the road at *e* near the farm house of Mr. Egbert.

The road then runs S. 60° W. About 200 feet on this course, and in a field north of the road, steatite and chlorite appear loose, but in great quantity, over a space 100 feet wide. Further on the road bears nearly due west, and the steatite showed itself in an excavation for a telegraph pole. The Roberts road crosses 200 feet further west, and on this, 200 feet south of the Black Rock road, is an exposure of steatite in place (*d*) ; the belt being 120 feet wide ; the strike S. 44° W. ; dip steep to south-east ; south-east wall not visible ; north-west wall garnetiferous mica schist.

From this point the belt may be traced by fragments in the field, about on the same course, to a point in the Black Rock road, at the bend just east of Mr. Charles Wheeler's place.

About 150 feet north-east of this bend (*c*), steatite and chlorite are visible in place.

West of this I know of no exposure.

If continuous, the rock should appear in the cut of the Pennsylvania railroad, which is about twenty-five feet deep and directly in the strike of the steatite. A very careful examination while the cut was being widened to make room for the fourth track failed to disclose the slightest trace of serpentine, steatite or allied minerals. There was nothing but mica schist mostly decomposed.

The Lafayette Serpentine belt.

The belt of *serpentine* in which Rose's quarry, *a* has been wrought, appears on the west side of the Schuylkill about three quarters of a mile north-west of the *steatite belt*, above described. There is also a small outcrop on the east side. It is in the main composed of a hard, very dark green, almost black, serpentine ; steatite and chlorite, which make up the mass of the steatite belt, are rare in it. At Rose's quarry it may be well examined.

Its strike is S. 40° to 60° W. ; its dip about 45° to 55° S. E.

To the south-east of it appears a thin bedded chlorite (?) schist.

On the south side of the quarry, and largely west of it,

occurs an *enstatite-like rock*, by the alteration of which the serpentine appears to have been formed. In fact in the quarry one bed is enstatite below, serpentine above.

Thence westward the serpentine and enstatite form a steep and very rocky hill, bearing about S. 40° W. and on the north-west side appears a rock which accompanies the serpentine westward. This rock is a "spangled mica schist" or gneiss, in which the mica is in small masses or isolated crystals, generally with curved surfaces remaining brilliant on exposure.

At a point about five-eighths of a mile from the river, and three-eighths of a mile from Rose's quarry, the serpentine is invisible except in scattered masses on the surface. Here there is a conspicuous oval knoll. At the east it consists of black hornblendic rock. Immediately on the west, and within a hundred feet (β) it is of steatite and chlorite, closely resembling the same minerals belonging to the *steatite* belt. Nothing but loose fragments appear, but in such abundance as to prove almost beyond doubt the underlying rock to be of the same character.

Thence the belt may be traced by surface fragments S. 40° W. ± about 800 feet (γ).

Thence S. 50° W. ± 300 feet to (δ) at the foot of the hill on its northern side.

Here a stream crosses, and beyond the stream the belt is very conspicuous and regular (ε) S. 47° W., bounded by the same schist rock, to a point (ζ).

Here the creek bottom intervenes for a distance of some 300 feet. At (η) the ridge again begins.

The course from ζ to η is S. 50° W., so that the belt seems to be shifted northward a short distance. It continues as a bold hill for about half a mile, running, except one curve, about S. 50° W. The hill then suddenly ends; but the rock may be traced by fragments to an ex posed outcrop, in the Conshohocken road, near the house of William Schallioll, and to the south of the former line of strike (ι).

Crossing the road to Bryn Mawr, east of a small stream, with a course of about S. 35° to 40° W., it seems to curve

even more southwardly; but as this is on a hill side it ma be due to creep.

About 400 feet further on in the same direction (λ) fra ments are found abundantly in a field. Through this pa of its course the bounding rock on the north appears to l a very thin bedded compact gneiss, with two and ofte three cleavages; and also the schist before mentioned.

North of this about 250 feet, just at the crossing of tw roads (μ) is another outcrop of serpentinous rock, or a hor blendic rock partially altered to serpentine; and abou 1,400 feet S. 60° W., a similar rock appears, forming a sma hill (η).

East of the Gulf road, and about S. 43° W. from the las fragments are found in a field.

West of the Gulf road is a conspicuous bluff of serpe tine dipping southwardly.

At Rosemont station, S. 45° W. from the last, an outcro (G) has been quarried, the rock having much the aspect (the "Bastard soapstone" of the steatite belt. This quar has been built over (1886).

West of this (at ο) fragments of quartz (apparently pseu domorphous after serpentine) are found; crossing the tur pike, no outcrop is known, I believe, until within a mile (Darby Creek, T, U.

Since the above was written an outcrop has been ol served on the Roberts road, about a half mile south-west (Rosemont station (R) on the property of Joseph F. Tobia It is not over twenty feet wide with mica schist on bot sides. Between this and the Old Lancaster road fragmen were found in a field.

At T the outcrop is very insignificant, at υ it is extensiv occupying nearly the whole of the space between Bry Mawr avenue and the Roberts road; from the Radnor an Chester road to near Darby creek, across which it agai outcrops on property of Moro Phillips, where chromic iro was mined, but I believe, not profitably. Thence it ex tends in a wide outcrop crossing the Philadelphia and We Chester road a mile east of Newtown Square. At this poi very fine stalactites of quartz were found. Thence sout

west it extends through Marple township to and beyond Crum creek.

At the Radnor and Chester road its appearance is very abrupt. On the north-east side of the road it is hardly visible, on the south-west side it is conspicuous of a breadth of two or three hundred feet. It is, at this point, largely enstatite passing into serpentine, as it is also in Marple.

If these steatite and serpentine belts be compared their unlikeness seems to point to a different origin.

As indicated by their names the former is largely steatite, the latter almost exclusively a very dark green, almost black serpentine.

The steatite belt contains numerous minerals—breunnerite, dolomite, aragonite, apatite, chlorite, chalcopyrite, magnetopyrite, millerite, magnetite, asbestos, Hallite, talc, actinolite. The serpentine belt contains very few,—varieties of serpentine, enstatite, chlorite (?), asbestos and aragonite being, I believe, the only minerals ever found in it, east of Darby creek. West of the creek chromite and some associated minerals occur.

The serpentine belt has undoubtedly resulted, in part at least, from the alteration of enstatite, as at Rose's quarry the passage of the enstatite into serpentine may be seen.

No such demonstration of the origin of the steatite belt is visible, the only clue to its origin is afforded by the serpentine crystals (pseudomorphs apparently after staurolite) best seen where the belt crosses Mill creek (Black Rock road) Lower Merion, but not rare at the soapstone quarry. These would indicate the alteration of a schist.

There is one remarkable exception to the individuality of these belts, the outcrop of the Lafayette belt at Rosemont; the rock at this point is wholly unlike that of any other part and closely resembles the "Bastard soapstone" or black rocks of the steatite belt.

North of the Philadelphia and West Chester road, about one mile east of Newtown Square, near the eastern limit of the serpentine, is a quarry in hornblende schist like that of the Philadelphia and Manayunk belts, but the schist appears to be changing into serpentine.

Serpentine west-south-west of Newtown Square.

This seems to be an easterly extension of the Castle R
enstatite converted into serpentine, but so far as I have
served, the serpentine and enstatite do not occur
gether.

Like the serpentines of Lafayette and Radnor it lies v
close to the Laurentian, which may be seen in a
tinct outcrop on the West Chester road three-quarters
mile west of Newtown Square at a fork, the south-
road leading to the serpentine and Castle Rock. The
bears S. 70° W. the Laurentian strikes about S. 75°
and the serpentine occurs in the road about half a mile f
the fork. If the Laurentian continues of the same st
the serpentine is within two hundred feet of it. This
crop is characterized by great quantities of quartz pse
morphous after the serpentine, the cavities lined with
stals, colorless, bright yellow and bright red. Some of
cavities contain myriads of microscopic quartz cry
(loose in a reddish mud). Many of these are perfect do
terminated crystals which make beautiful polarizing obj
for the microscope, under which the coloring matter is
to occupy but a small part of the crystal, the rest b
colorless and perfectly transparent.

Limonite with fibres two or three inches long occurs h

Between this and the belt east of Newtown Square,
country is highly cultivated, and exposures are infrequ
but what there are show mica schists and gneisses w
do not closely resemble any others of the region.

Radnor Serpentine belt.

The largest and most prominent belt of serpentine in
nor township begins, easterly, on the Mattson's Ford
about three-eighths of a mile east of Radnor station, a
one-eighth of a mile west of the Montgomery county lin
the western side of a small affluent of Gulf creek. (10
the map). It forms a bold hill about 200′ across. The
posite hill is steep, with Laurentian fragments, witho
trace of serpentine. The outcrop crosses the road wi
strike nearly west. The following dips were obtained

the south-east edge but are probably of little value, N. 45° W. 65°; N. 25° W. 65°; N. 22° W. 80°.

The length of this outcrop is about 700′ to a small valley, on the northern side of which (⅛ mile S. 65° W.) is a second but insignificant outcrop (102).

The rock in contact with the serpentine is concealed, but on the south, east, and north the soil is filled with Laurentian fragments; and about 300′ north of 101 is a quarry in Laurentian, which also is exposed in the bed of Gulf creek about 600′ north with dips S. 25 E. 70° and S. 15 E. 70°. On the north-east is a hill with Laurentian outcrops, around which the road curves to the north. On the south-east side of this hill the rock dips S. 5° E. 74° and in the road near S. 8° E. 80°, strike N. 60° E. vertical N. 30° E. 70°, but these are not entirely trustworthy.

At 103, on the western side of the road from Radnor station to King of Prussia, the serpentine again appears and continues about S. 60° W. 1000′. If the line of strike of outcrops 101–102 be extended it will meet this outcrop about its centre. At the southwestern end it has been quarried (Stacker's quarry), and there were strong indications of a synclinal (see plate page 1570), but there is much doubt whether the seams are bedding planes, or cleavage lines, or irregular joints. They are very irregular, and throughout the quarry often run to thin edges, as at c–d–e. In a well, fifty-two feet deep near by, the same irregularity occurs, and no regular stratification can be seen. Near the southern edge of the serpentine, on the adjoining land of Theo. D. Rand, a mass of serpentine had a nucleus of unaltered enstatite. The serpentine hill ends as abruptly as it began, but to the north-west about 300 feet is a small outcrop on the land of Henry A. Geisse (see plate page 1586) with a strike N. 30° E. and dips 30° to 80° to the south-east. Due west from this and within 200 to 300 feet are Laurentian rocks, loose, but in large masses, while within the line of strike and within 50′ of abundant continuous serpentine fragments is a well in Rogers' altered primal much decomposed dipping to the south-east, striking N. 70° E. East of it is Laurentian exposed along

the Radnor and King of Prussia road and also in a wel

At all these outcrops the rock is largely a very dark com pact serpentine resembling strongly that of the Lafayett belt. It is sometimes green, but never, unless weathered, light color. Much of it appears as if it had been an enstatit like mineral and was not quite changed into serpentin On Stacker's property at the south-west edge of the quarr the change of the serpentine into the honey-comb quartz, s abundant here as well as at other serpentine outcrops, is we shown. At the lower part, the serpentine is almost un altered, above small seams appear containing quartz films higher up these films become thicker and the serpentin becomes more disintegrated, until near the top, the quartz is some 2″ thick and the serpentine almost gone. Masse of this quartz, almost solid, and weighing upwards of 20 pounds have been found.

In the serpentine few minerals occur. At the Stacke quarry, chrysotile, asbestus, marmolite, serpentine pseu domorph after asbestus, and chlorite have been found, an at Rand's chromite, Genthite, enstatite, mountain cork an deweylite; at both, drusy quartz, chalcedony, &c.

At outcrops 103–104 the rocks immediately in contac with the serpentine are not visible but on the south-wes Laurentian rocks occurred certainly within 200′ and frag ments are abundant in the soil. On the south-west Rogers altered primal is exposed within about 200′ north-wes of 103 and 104, also in the above mentioned well, whil garnetiferous mica schist was found in a well about 300 fee N. 85° E. from the last. (See plate p. 1586).

West of this no outcrops are known for about two miles then in Tredyffrin, in the valley nearly south of old Eagl station, is the fifth outcrop, whence some stone has bee quarried. The outcrop is small and the strike indistinct the sixth, south-west of Eagle, east of and near the roa between Delaware and Chester counties, is S. 70° W. from the former, the strike is S. 40° W., the dip 70° to 80° south east. This quarry has been extensively wrought to supply building stone for the Devon Inn, and the exposur is good.

The seventh exposure is in Easttown about 300 feet west and a little north from Devon Inn and nearly due west of the large quarry. The exposure is small but the strike is very clearly S. 40° W. In a recent excavation, a surface exposure was S. 50° to 60° W. The dip 55° to the south-east.

The eighth is a little south of west of the seventh, strike and dip not distinct. The ninth, that crossing the road running south-east from Berwyn, and about a mile from that station, is at its eastern end S. 10° W. from the eighth, its strike is S. 40° W.

The extensive belt south of Paoli is in Willistown, nearly west from this, and extends thence as the wide and well-known belt passing one mile north of West Chester.

A glance at the map will show that these outcrops, though on a line bearing nearly east and west, all cross that line at angles, striking more north-east and south-west except the first. This is very evident on the ground. An observer standing on the brow of quarry E. of Devon at its south-west end, sees before him a valley bounded on the north side by the hydro-mica South Valley Hill and on the south by the Laurentian gneiss hill. In front of him the serpentine in the quarry is seen to strike towards the hydro-mica at a considerable angle; while the fifth outcrop, in plain sight, is not in line at all. The same may be seen at outcrops further west but not so distinctly.

On the Northerly Serpentine Belt in Radnor Township, Delaware County and in Lower Merion, Montgomery County.

The most easterly outcrop (2) is in the Gulf road, 500 feet south of the Mattson's Ford, or township line road, except a small exposure (1) of surface fragments, two or three hundred feet east of this outcrop.

Here the rock is a serpentine, dark green with portions of red; it is bounded north apparently by the hydro-mica schists of the Gulf hills decomposed (or at least they are very near); on the south by (Roger's altered primal).

The next outcrop (3) is at a small house on the Mattson's Ford road 400 feet east of the county line road (between

Delaware and Montgomery counties) and opposite th house, in the field (4); this is about S. 60° W. from th former. Near this a garnetiferous mica schist occurs. I is not visible in place.

About one-fourth of a mile S. 85° W. of this, is an out crop on the property of Judge Hare. Here the rock wa exposed by a ditch, steatite, serpentine and chlorite bein found, with a garnetiferous mica schist; and perhaps o both sides of the belt and certainly on the north-west th altered primal of Rogers, thin bedded, gneissic rocks.

The same steatite rocks were also exposed in a cellar du for a house on the Radnor and King of Prussia road abou 500′ south of Gulf creek. This lies about half a mile almos due west from the outcrop at Judge Hare's, almost ex actly the bearing and distance of the outcrops of the large belt to the south, and quite different from the usual strik of the region and of these rocks themselves in local ex posures.

[The steatite exposure in Judge Hare's drain, was ex amined by Mr. C. E. Hall who reported as follows :

The steatite belt here occupies the ground south of Gul creek and between it and one of its southern affluent which rises near Radnor station.

The outcrop cuts across the drain, in a south-west direc tion, and that is all that can be said of it. It was not ex posed well enough to give a dip, or even the true strike although the strike seems conformable with that of th syenite rocks of the neighborhood; and therefore in th direction of the serpentine at Mr. Rand's house; but Mr Hall, who examined the locality, inclined to the opinio that while both serpentine and steatite were associated wit the syenites, they were individually distinct members o the series; and not two exposures along the same outcro line, with two different characters at the two points on th line. He adds:

"Although having the same strike as the syenites, it i not necessary to suppose that they are conformable. Th dips obtainable at serpentine localities are worthless.

"I conclude that the serpentine group of N. E. Dela

ware county has been deposited non-conformably upon the syenite rocks; and to an extent rolled up and contorted with them; being left in lenticular patches [of theoretically synclinal shape] parallel to the strike of the syenites.

"In all probability, there are two groups of serpentines. The above mentioned group does not seem to have slates associated with it, unless possibly the South Valley Hill slates.

"The serpentine group which extends from Chestnut Hill to Bryn Mawr and the serpentines of Delaware county are associated with schists, which do not appear any where through the northern part of Radnor township.

"The cellar excavation of Judge Hare shows syenite rock of which the upper edges appear to have been broken to pieces and the spaces filled up with surface soil.]

Comparing the rocks on each side of the Laurentian the similarity is striking, but not without equally striking differences. On the north (strictly N. W.) we find the altered primal on the south an almost identical rock; on the north mica schists and garnetiferous schists; on the south almost identical rocks. Close to these on both sides is the white sandstone, undoubtedly Potsdam, on the north side. On both sides occur also two belts of serpentine rocks, the inner of very dark serpentine resulting from the alteration of enstatite, the outer largely steatite with lighter serpentine. The serpentine is almost continuous a long distance; the steatite is not.

On the north, however the serpentine is almost certainly within the Laurentian; on the south the altered primal and spangled mica schist intervene. On the north the white sandstone is beyond the steatite; on the south it is close to the serpentine.

It does not seem possible, with our present knowledge, to construct a satisfactory section through this region from the Chester valley to the Delaware; but I think there can be little doubt that the mica schists and sandstone of Cream valley are repeated on the south-east of the Laurentian axis; and that between the two steatite belts the. structure is a simple anticlinal. South-east of this the mica schists, por-

phyritic gneiss and Fairmount gneiss, with the intervening mica schists, require more study; but it seems not incredible that the first named may be the same as the hydro-mica schists. The resemblance between the decomposing hydro-mica schists at the crossing of the Mattson's Ford and Gulf roads and the mica schists at Byrn Mawr (L. M.) is very close.

In these notes it has been my object to make an accurate record of the outcrops of the various rocks, rather than to uphold any theory, believing that if a careful thorough mapping of this region be made, advantage being taken of chance exposures in recent cuttings, wells, &c., wherever possible, the time will not be far distant when we shall no longer have to admit that we do not know the geological structure of a part of our State which has been so long studied. As a small contribution to this end these observations are offered.

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LIST OF

THE PUBLICATIONS

OF THE

GEOLOGICAL SURVEY OF PENNSYLVANIA.

FROM 1874 TO 1888.

ANNUAL REPORTS.

1885 ANNUAL. J. P. Lesley, State Geologist, 8°, 769 pp., with preface and index, accompanied by Atlas 8°, 8 pl., and maps, 1886, contains following special reports:

1. Oil and Gas. John F. Carll.
2. Vegetable Origin of Coal. Leo Lesquereux.
3. Pittsburg Coal Region. E. V. d'Invilliers.
4. Wellersburg Coal Basin. J. P. Lesley and E. B. Harden.
5. Tipton Run Coal Basin. C. A. Ashburner.
6. Anthracite Coal Region. C. A. Ashburner.
7. Wyoming Valley Fossils. C. A. Ashburner and A. Heilprin.
8. Bernice Coal Basin. C. A. Ashburner.
9. Mehoopany Coal Field. F. A. Hill.
10. Cornwall Ore Mines. J. P. Lesley and E. V. d'Invilliers.
11. Delaware and Chester Kaolins. J. P. Lesley and C. A. Ashburner.
12. Quaternary Geology, Wyoming Valley. C. A. Ashburner, F. A. Hill, and H. C. Lewis.
13. Pressure, &c., of Rock Gas. J. P. Lesley.
14. Progress Geodetic Survey. Mansfield Merriman.

1886 ANNUAL. J. P. Lesley, State Geologist, 8°, in four parts, as follows:

i. Pittsburgh Coal Region. E. V. d'Invilliers.
ii. Oil and Gas Region. J. F. Carll, F. C. Phillips, B. S. Lyman.
iii. Anthracite Coal Region with Atlas. F. A. Hill.
iv. 1. The Lehigh River Cross Section. Arthur Winslow.
 2. Paint Ores along the Lehigh River. F. A. Hill.
 3. Iron Ore Mines and Limestone Quarries of the Cumberland-Lebanon Valley. E. V. d'Invilliers.
 4. Geology of Radnor township, Delaware co., &c. T. D. Rand. With an Atlas.

MISCELLANEOUS REPORTS.

A. A history of the FIRST GEOLOGICAL SURVEY of Pennsylvania, f 1836 to 1858, by J. P. Lesley. With the annual reports of the Board to Legislature for 1874 and 1875. 8°, pp. 226, 1876.

B. Report on the MINERALS of Pennsylvania, by F. A. Genth; and or hydro-carbon compounds, by S. P. Sadtler. With a reference map of State. 8°, pp. 206, 1875.

B2. Report on the MINERALS, by F. A. Genth, continued from page to 238. 8°, in paper cover, pp. 31, 1876. (Bound with B.)

M. Report of CHEMICAL ANALYSES in 1874–5, in the Laboratory at Ha burg, by A. S. McCreath. 8°, pp. 105, 1875.

M2. Report of CHEMICAL ANALYSES in 1876–8, by A. S. McCreath; Cl fication of coals, by P. Frazer; Fire-brick tests, by F. Platt; Dolomitic li stone beds, by J. P. Lesley; Utilization of anthracite slack, by F. Platt; termination of Carbon in iron or steel, by A. S. McCreath. With one fo plate (section at Harrisburg) and four page plates. 8°, pp. 438, 1879.

M3. Report of CHEMICAL ANALYSES in 1879–80, by A. S. McCreath. W a reference map of 93 iron ore mines in the Cumberland Valley. 8°, pp. 1881.

N. Report on the LEVELS above tide of railroads, canal and turn stations, mountain tops, &c., in and around Pennsylvania, in 200 tables C. Allen. With a map. 8°, pp. 279, 1878.

O. CATALOGUE of specimens collected by the survey, (No. 1 to No. 4,2 by C. E. Hall. 8°, pp. 217, 1878.

O2. CATALOGUE (continued from No. 4,265 to No. 8,974); also catalog fossils, (pp. 231 to 239.) 8°, pp. 272, 1880.

P. Report on the COAL FLORA of Pennsylvania and the United St Vols. 1 and 2, (bound together,) by L. Lesquereux. 8°, pp. 694, 1880.

P. Report on the COAL FLORA of Pennsylvania and the United St Vol. 3, with 24 double page plates (lithographed) of coal plants, to accomp P., Vols. 1 and 2. 8°, pp. 283, 1884.

(P.) ATLAS of 87 double page plates (lithographed) of coal plants to company P., Vols. 1 and 2. 8°, 1879.

P2. Report on Permo-Carboniferous plants from W. Va. and Greene cou Pennsylvania, by W. M. Fontaine and I. C. White. With 38 double plates (lithographed). 8°, pp. 143, 1880.

P3. Description of *Ceratiocaridæ*, by C. E. Beecher; and of *Eurypter* by James Hall. With 8 plates. 8°, pp. 39, 1884.

Z. Report on the TERMINAL MORAINE across Pennsylvania, by H. Lewis; including extracts from descriptions of the Moraine in New Jer by G. H. Cook, and in Ohio, Kentucky and Indiana, by G. F. Wright. a map of the State, 18 photographic views of the Moraine, and 32 page p maps and sections. 8°, pp. lvi and 299, 1884.

GRAND ATLAS, Div. I, Pt. I, 1885, port-folio containing maps of 56 coun and parts of counties (scale 2 miles to 1 inch) on 49 sheets (26″×32″.) T maps are duplicate prints on heavy paper of the county maps containe the reports of progress.

Annual Report, 1886. Part IV.

ANTHRACITE REGION.

A2. Report on the causes, kinds and amount of WASTE in mining ant c ite, by F. Platt; with a chapter on METHODS of mining, by J. P. Weth

Illustrated by 35 figures of mining operations, a plan of the Hammond breaker, and a specimen sheet of the maps of the Anthracite coal fields. 8°, pp. 134, 1881.

AC. Report on MINING METHODS, &c., in the anthracite coal fields, by H. M. Chance. Illustrated with 54 plates and 60 illustrations in the text. 8°, pp. 574, 1883.

(AC.) ATLAS containing 25 plates illustrating coal mining, to accompany Report AC, by H. M. Chance. 8°, 1883.

AA. First report of progress of the anthracite survey; PANTHER CREEK BASIN, by C. A. Ashburner; with a determination of the latitude and longitude of Wilkes-Barre and Pottsville, by C. L. Doolittle; and a theory of stadia measurements, by A. Winslow. 8°, pp. 407, 1883.

AA. Second report of progress of the anthracite survey, Part I; Statistics of Production and Shipment for 1883 and 1884. Charles A. Ashburner, geologist in charge.

(AA.) ATLAS OF SOUTHERN anthracite field, Part I, containing 13 sheets; 3 geological and mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical map sheet, and 1 coal bed area sheet, relating to the PANTHER CREEK BASIN; 1 general map of the anthracite region, and 1 chart of anthracite production from 1820 to 1881. 8°, 1882. Charles A. Ashburner, geologist in charge; A. W. Sheafer and Frank A. Hill, assistant geologists.

(AA.) ATLAS OF WESTERN MIDDLE anthracite field, Part I, containing 11 sheets; 4 geological and mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4 cross section sheets. 8°, 1884. Charles A. Ashburner geologist in charge; A. W. Sheafer and Bard Wells, assistant geologists.

(AA.) ATLAS OF WESTERN MIDDLE anthracite field, Part II, containing 11 sheets; 4 geological and mine sheets from Mount Carmel to the western end of the coal field, and 7 columnar section sheets covering the entire field. 8°, 1887. Frank A. Hill, geologist in charge; Bard Wells, assistant geologist.

(AA.) ATLAS OF NORTHERN anthracite field, Part I, containing 6 geological and mine sheets between Wilkes-Barre and Nanticoke, 3 cross section sheets and 4 columnar section sheets. 8°, 1885. Charles A. Ashburner, geologist in charge; Frank A. Hill, assistant geologist.

(AA.) ATLAS OF NORTHERN anthracite field, Part II, containing 10 sheets; 4 mine sheets relating to that portion of the Wyoming-Lackawanna coal basin between Wyoming and Taylorville, and 2 topographical and mine sheets relating to the extreme western end of the Wyoming basin; 4 columnar section sheets of bore-holes, shafts and tunnels. 8°, 1887. Frank A. Hill, geologist in charge; William Griffith, assistant geologist.

(AA.) ATLAS EASTERN MIDDLE anthracite field, Part I, containing 8 sheets, 2 geological and mine sheets in the vicinity of Hazleton, Drifton and surrounding towns, 3 cross section sheets and 3 columnar section sheets. 8°, 1885. Charles A. Ashburner, geologist in charge; A. P. Berlin and Arthur Winslow, assistant geologists.

(AA.) ATLAS OF EASTERN MIDDLE anthracite field, Part II. In Press.

GRAND ATLAS, Div. II, Pt. I, 1884. Port-folio containing 26 sheets, (26"× 32"), as follows: 13 sheets Atlas Southern Anthracite Field, Part I, 11 sheets Atlas Western Middle Anthracite Field, Part I, 1 sheet photo views of plaster models in Western, Middle and Southern Fields, and 1 specimen sheet, Report A 2.

GRAND ATLAS, Div. II, Pt. II, 1885. Port-folio containing 22 sheets, (26'
32 '), as follows: 13 sheets Atlas Northern Anthracite Field, Part I, 8 she
Atlas Eastern Middle Anthracite Field, Part I, and one sheet containing a p
liminary general map of the Anthracite Coal Fields and adjoining counti

For Anthracite coal in SULLIVAN county, see G 2 and Annual Report, 1

For Conglomerate beds near Carbondale, Pittston, &c., see G 5, G 7.

For Utilization of anthracite slack, see M 2.

For General description anthracite region, Quaternary Geology of
Wyoming-Lackawanna Valley, &c., &c., see Annual Report, 1885.

Annual Report, 1886. Part III.

BITUMINOUS COAL FIELDS AND SURROUNDING AREA

H. First report on CLEARFIELD and JEFFERSON counties, by F. Pl
With 8 maps, 2 sections and 139 cuts in the text. 8°, pp. 296, 1875. (*F
second report, see H 6, H 7.*)

H 2. Report on CAMBRIA county, by F. & W. G. Platt. With 4 maps a
sections and 84 cuts in the text. 8°, pp. 194, 1877.

H 3. Report on SOMERSET county, by F. & W. G. Platt. With 6 ma
and sections and 110 cuts in the text. 8°, pp. 348, 1877.

Atlas to Reports H^2 and H^3 containing geological maps of Cambria a
Somerset counties, with columnar and cross sections. In Press.

H 4. Report on INDIANA county, by W. G. Platt. With a colored geo
gical county map and 87 cuts in the text. 8°, pp. 316, 1878.

H 5. Report on ARMSTRONG county, by W. G. Platt. With a colored g
logical county map and 58 cuts in the text. 8°, pp. 338, 1880.

H 6. Second report on JEFFERSON county, (*See H above*), by W. G. Pl
With a colored geological county map and 57 cuts in the text. 8°, pp.
1881.

H 7. Second report on CLEARFIELD county, (*See H above*), by H.
Chance. With a colored geological county map, an outcrop map of
Houtzdale basin and 58 cuts in the text. 8°, pp. 197, 1884.

I. Report on VENANGO county, by J. F. Carll. The geology arou
Warren, by F. A. Randall. Notes on the comparative geology of N.
Ohio, N. W. Pa., and W. New York, by J. P. Lesley. With one small m
of the Venango oil region, one small map of the region south and eas
Lake Erie, one long section of the rocks at Warren, and 7 cuts in the te
8°, pp. 127, 1875.

I 2. Report of oil well records and levels in VENANGO, WARREN, CRA
FORD, CLARION, ARMSTRONG, BUTLER, &c., by J. F. CARLL. 8°, pp.
1877.

I 3. Report on the VENANGO, WARREN, CLARION, and BUTLER OIL R
GIONS; descriptions of rig, tools, &c.; survey of the Garland and Pana
conglomerates, &c.; discussion of pre-glacial and post-glacial drainage,
J. F. Carll. With 23 page plates and an atlas. 8°, pp. 482, 1880.

(I 3.) Atlas of 22 sheets. Map of Venango county, colored geological
map of lower oil field (Butler, Armstrong, and Clarion) in two sheets
local contour maps at Franklin, Titusville and Spring Creek; two maps
N. W. Pennsylvania, showing the past and present drainage; long sect
across W. Pennsylvania; vertical section of the formations from the Up
Coal measures down to the bottom of the Devonian; diagram map and s
tion of Third sand; profile section from Meadville, S. W.; 5 sheets
grouped oil well sections; 5 sheets of working drawings for well bori
&c.; diagram of daily rate of drilling six wells at Petrolia.

4. Report on WARREN county, by J. F. Carll. With a colored geologi-
county map, a map of the Warren oil region, and 2 sheets of oil well
ions. 8°, pp. 439, 1883. (*Note—The first 147 pages of this book contain*
well records; see under Petroleum Fields below.)
. Report on the OIL REGION, by H. E. Wrigley; map and profile of line
evels through Butler, Armstrong, and Clarion, by D. J. Lucas; map and
file of Slippery Rock creek, by J. P. Lesley. 5 maps and sections, a
e and 5 cuts. 8°, pp. 122, 1875.
. Report on GREENE and WASHINGTON counties, by J. J. Stevenson.
h two county maps. (Showing the calculated local depths of the Pitts-
gh and Waynesburg coal beds beneath the surface,) and 3 page plates of
eral sections. 8°, pp. 419, 1876. (*Note.—Since the publication of this*
t two colored geological county Maps have been published, and will be
nd in pocket of volume K 3 described below.)
2. First report on FAYETTE, WESTMORELAND and S. E. ALLEGHENY
nties, (*i. e.*, west of Chestnut Ridge,) by J. J. Stevenson. With 3 col-
l geological county maps and 50 cuts in the text. 8°, pp. 437, 1877.
3. Second report on FAYETTE and WESTMORELAND counties (the Lig-
r Valley), by J. J. Stevenson. With 4 page plates and 107 cuts in text.
pp. 331, 1878. (*Note.—In a pocket in this volume will be found the col-*
l geological maps of Greene and Washington counties alluded to above.)
4. Pt. I, Report on MONONGAHELA RIVER COAL MINES, from the West
ginia State Line to Pittsburgh, (including some on the Youghiogheny
other streams), by J. Sutton Wall. With a map of the region in a
ket, 12 heliotype pictures, and 26 page plates. 8°, pp. 231, 1884.
Report on the YOUGHIOGHENY coke manufacture, by F. Platt; Notes
he coal and iron ore beds, by C. A. Young: Report on methods of coking
. Fulton, (*See G* below); Report on the use of natural gas in the iron
ufacture, by J. B. Pearse and F. Platt; The Boyd's Hill gas well at Pitts-
gh, by J. P. Lesley. With a map of the coke region, two folded plates
oke ovens, and page plates and cuts in the text. 8°, pp. 252, 1876.
Report on BEAVER, N. W. ALLEGHENY and S. BUTLER counties by
White. With 3 colored geological county maps, and 21 page plates of
ions. 8°, pp. 337, 1878.
2. Report on LAWRENCE county, and special Report on Correlation of
Pennsylvania and Ohio coal beds, by I. C. White. With a colored geo-
al county map and 134 cuts in the text. 8°, pp. 336, 1879.
3. Report on MERCER county, by I. C. White. With a colored geolo-
county map and 119 cuts in the text. 8°, pp. 233, 1880.
4. Report on CRAWFORD and ERIE counties, by I. C. White. With
colored geological county maps and 107 cuts in the text. Also, a Report
pre-glacial outlet for Lake Erie, by J. W. Spencer. With two maps of
Lake region. 8°, pp. 406, 1881.
Report on McKEAN county, and its geological connections with Came-
Elk, and Forest counties, by C. A. Ashburner. With 33 page plates of
ical and columnar sections, pictures of Rock city and Olean conglomer-
Wilcox and Kane spouting wells, map of Howard Hill coal field, &c.,
an atlas of 8 sheets. 8°, pp. 371, 1880.
1.) ATLAS for McKean county of 8 sheets:—Colored geological county
; three topographical maps; of Buffalo Coal Company tract, Alton coal
n, and Potato Creek coal basin: map of McKean oil district; one sheet
olumnar sections between Bradford and Ridgway; and 2 diagram sheets
he Well account and Production account in the Bradford district.

R 2. Part II, report on township geology of CAMERON, ELK and Fo
counties, by C. A. Ashburner.

(**R 2.**) ATLAS for CAMERON, ELK and FOREST counties, of 11 sl
(*Published November, 1884, in advance of the report*) :—3 colored geo
cal county maps; 1 anticlinal and synclinal map; 1 topographical
McKean county; 2 tract maps Forest and Elk counties; 1 map Str
Creek coal basin; 2 sheets oil well sections; and 1 sheet coal sections.

V. Report on N. BUTLER county; and (Part 2) special report on
Beaver and Shenango river coal measures, by H. M. Chance. Wi
colored geological map of N. Butler; a contour local map around Pa
a map of the anticlinal rolls in the 6th basin; a chart of the Beaver
Shenango rivers; profile section from Homewood to Sharon; Oil
records and surface sections; and 154 cuts in the text. 8°, pp. 248, 187

V 2. Report on CLARION county, by H. M. Chance. With a colored
logical county map, a map of the anticlinals and oil-belt; a contoured
of the old river channel at Parker; 4 page plates, and 83 cuts in the
8°, pp. 232, 1880.

For the coal basins of BRADFORD and TIOGA counties, see report G.

For the coal basins of LYCOMING and SULLIVAN, see report G 2.

For the coal basins of POTTER county, see G 3.

For the coal basins of CLINTON county, see G 4.

For the coal in WAYNE county, see G 5.

For the East Broad Top coal basin in HUNTINGDON county, see F.

For the mountain coals in BLAIR county, see T.

For the Broad Top coal measures in BEDFORD and FULTON counties, se

For the coal basins in CENTRE county, see T 4.

For coal analyses, see M, M 2, M 3.

For classification of coals, see in M 2.

For coal plants, see P, P 2.

For fossil crustaceans in coal slate, see P 3.

For Origin of Coal; Pittsburgh Region and Monongahela Valley; We
burg coal basin, Somerset county; and Tipton Run coal-beds, Blair cou
see Annual Report, 1885.

Grand Atlas Div. III, Pt. I, 1885, port-folio containing 35 sheets (26"×
as follows: 32 sheets relating to portions of the Petroleum and Bitumi
Coal Fields, and three sheets relating to the Quaternary period.

Annual Report, 1886. Part I.

PETROLEUM AND GAS.

See reports I, I 2, I 3, I 4, and J, under Bituminous Coal Fields.

See L, for the Pittsburgh gas well, and the use of gas in the iron manufac

See Q, Q 2, Q 3, Q 4, for references to oil rocks in Beaver, Lawrence,
cer, Crawford, Erie, and S. Butler counties.

See K for the Dunkard Creek oil wells of Greene county.

See R, R 2, for descriptions of oil rocks in McKean, Elk, and F
counties.

See V, V 2, for notes on the oil rocks of N. Butler and Clarion counti

See H 2 for oil boring at Cherry Tree, Cambria county.

See G 5 for oil boring in Wayne county.

See Annual Report, 1885, for report of progress in the oil and gas re
with special facts relating to the geology and physics of natural gas.

See Grand Atlas, Div. III, Pt. I, under Bituminous Coal Fields.

See Annual Report, 1886. Part II.

NORTH-EASTERN AND MIDDLE PENNSYLVANIA.

(*Palæozonic formations from the Coal Measures down.*)

First report on LEHIGH county iron mines, by F. Prime. With a con-
line map of the ore region and 8 page plates. 8°, pp. 73, 1875.

. Second report on LEHIGH county iron mines, by F. Prime. With a
ed geological contour line map of the iron region, (in 4 sheets,) a colored
gical contour line map of the Ironton mines, 4 double page lithograph
res of Limestone quarries, and one page plate of *Monocraterion.* 8°,
, 1878.

. Vol. I. Report on LEHIGH and NORTHAMPTON counties. Introduc-
y J. P. Lesley; Slate belt, by R. H. Sanders; Limestone belt and iron
, by F. Prime; South mountain rocks, by F. Prime and C. E. Hall.
3 lithograph pictures of quarries, 4 pictures of triangulation stations, 14
plates of sections, and an atlas of maps. 8°, pp. 283, 1883. (*Note.—For
see below.*)

. Vol. II, Part I. Report on BERKS county, (*South mountain belt*) by
d'Invilliers. With 10 page plates of sections and Indian relics, and
ures of rock exposures. 8°, pp. 441, 1883. (*Note.—For atlas see below.*

.) ATLAS: One colored geological map of *Lehigh* and Northampton
ies, (*one sheet;*) one colored geological contour line map of Southern
ampton county, (*six sheets;*) a contour line map of the mountains from
elaware to the Schuylkill, (*eighteen sheets;*) a colored geological con-
ine index map to the 22 sheets, (*one sheet;*) and 4 sheets of maps of
ines.

.) ATLAS of colored geological county maps of CUMBERLAND, FRANK-
nd ADAMS, (*three sheets;*) and first instalment of contour line map of
outh mountains, Sheets A 1, A 2, B 1, B 2, (*four sheets;*) by A. E.
an.

Report on the JUNIATA RIVER district in MIFFLIN, SNYDER, and HUN-
ON counties, by J. H. Dewees, and on the Aughwick valley and East
Top region in HUNTINGDON county, by C. A. Ashburner. With col-
geological maps of East Broad Top R. R. and Orbisonia vicinity, (2
;) Three Springs map and section, (2 sheets;) Sideling Hill Creek map
ction, (2 sheets,) and Isometric projection at Three Springs, (1 sheet;)
ded cross sections and 22 page plates of local maps and columnar sec-
8°, pp. 305, 1878.

Report on PERRY county, (*Part 1, geology,*) by E. W. Claypole.
two colored geological maps of the county; 17 geological outline town-
maps as page plates, and 30 page plate cross and columnar sections. 8°,
, 1884.

Report on BRADFORD and TIOGA counties, by A Sherwood; report on
oal fields, (including forks of Pine creek in Potter county,) by F. Platt;
on the COKING of bituminous coal, by J. Fulton. (*See L above.*) With
lored geological county maps, 3 page plates, and 35 cuts in the text.
. 271, 1878.

Report on LYCOMING and SULLIVAN counties; field notes by A. Sher-
; coal basins by F. Platt. With two colored geological county maps (o
ing and Sullivan,) a topographical map (in two sheets) of the Little
reek coal basin, and 24 page plates of columnar sections. 8°, pp. 268,

G 3. Report on POTTER county, by A. Sherwood. Report on its c FIELDS, by F. Platt. With a colored geological county map, 2 folded pl and 2 page plates of sections. 8°, pp. 121, 1880.

G 4. Report on CLINTON county, by H. M. Chance, including a desc tion of the Renovo coal basin, by C. A. Ashburner, and notes on the Tan cootac coal basin, by F. Platt. With a colored geological county map, 1 sl of sections, local Renovo map, 6 page plates, and 21 sections in the text. pp. 183, 1880.

G 5. Report on SUSQUEHANNA and WAYNE counties by I. C. Wh With a colored geological map of the two counties and 58 cuts in the text. pp. 243, 1881.

G 6. Report on PIKE and MONROE counties, by I. C. White. With colored geological county maps, (1 sheet Pike and Monroe and 1 sheet oming), a map of glacial scratches, and 7 small sections. Report on Delaware and Lehigh Water Gaps, with two contoured maps and five tions of the gaps, by H. M. Chance. 8°, pp. 407, 1882.

G 7. Report on WYOMING, LACKAWANNA, LUZERNE, COLUMBIA, M TOUR and NORTHUMBERLAND counties, (i. e., the parts lying *outside* of anthracite coal fields), by I. C. White. With a colored geological ma these counties (in two sheets), and 31 page plates in the text. 8°, pp. 1883. (*Note.—The colored geological map of* WYOMING *county is publis in G 6.*

T. Report on BLAIR county, by F. Platt. With 35 cuts in the text and Atlas of maps and sections (see below). 8°, pp. 311, 1881.

(T.) Atlas of colored geological contour line map of Morrison's co Canoe valley, Sinking valley and country west to the Cambria county (14 sheets); Index map of the same (1 sheet); colored sections (2 shee 8°, 1881.

T 2. Report on BEDFORD and FULTON counties, by J. J. Stevenson. W two colored geological maps of the two counties. 8°, pp. 382, 1882.

T 3. Report on HUNTINGDON county, by I. C. White. With a colo geological map of the county, and numerous sections. 8°, pp. 471, 1885.

T 4. Report on CENTRE county, by E. V. d'Invilliers; also special rep by A. L. Ewing, and extracts from report to Lyon, Shorb & Co., by J Lesley. With a colored geological map of the county, 13 page plates of lo maps and sections, and 15 cuts in the text. 8°, pp. 464, 1884.

For report on line of the Terminal Moraine, see Z.

GRAND ATLAS, Div. IV, Pt. I, 1885. Port-folio containing 43 sheets, follows: 30 sheets relating to the Durham and Reading Hills and border valleys in Northampton, Lehigh, Bucks and Berks counties, and 13 she relating to the South Mountains in Adams, Franklin, Cumberland York counties.

GRAND ATLAS, Div. V, Pt. I, 1885. Port-folio containing 35 sheets, as lows: 29 sheets relating to the Topography and Geology of the Palæo strata in parts of Cambria, Blair, Bedford, Huntingdon, Mifflin, Centre Union counties, 5 sheets contain a map and geological cross section al the east bank of the Susquehanna river, Lancaster county, and 1 sheet c tains cross sections of the Philadelphia belt of the Azoic rocks.

For report on Cornwall Iron Ore Mines, Lebanon county, and the Tip Run coal beds, Blair county, see Annual Report, 1885.

For report on the Iron Ore Mines and Limestone Quarries of the Cumb land-Lebanon Valley, see Annual, 1886, Part IV.

SOUTH-EASTERN PENNSYLVANIA.

eport on YORK and ADAMS counties, by P. Frazer. With one folded a belt of York county through York and Hanover, 6 folded cross s, and two page plate microscopic slices of dolerite. 8O, pp. 198, 1876. e.—*The colored geological county map of* YORK *is published in the to C 3*).

Report on YORK and ADAMS counties, (South Mountain rocks, iron c.), by P. Frazer. With one general map of the district, 10 folded ections, and 5 page plates. 8O, pp. 400, 1877. (*Note.—The colored cal county map of* ADAMS *is published in D 5*).

Report on LANCASTER county, by P. Frazer. With nine double page phic views of slate quarries and Indian-pictured rocks, one plate of sions on slate, and one page plate microscopic section of trap, and an 8O, pp. 350, 1880.

) ATLAS of 13 sheets: Colored geological map of York county; col-ological map of LANCASTER county; Susquehanna river section. 1, 1A, 2, 2A, 3, 4); Lancaster section; Pequea section; Muddy run ; Chestnut Hill mines; Gap Nickel mine.

Report on CHESTER county; General description, pp. 214, by J. P ; Field notes in the townships, pp. 215–354, by P. Frazer. With a geological county map, a photographic view of contorted schists and plates. 8O, pp. 394, 1883.

Report on DELAWARE county, by C. E. Hall. With a colored geolog-unty map; 30 photographic page plate views of granite quarries, pits, &c., and 4 page plates of altered mica. 8O, pp. 128, 1885. See Report, 1885, for Kaolin report.

Report on PHILADELPHIA and the southern parts of MONTGOMERY CKS counties, by C. E. Hall. With a colored geological map of the country between Trenton and Delaware county (in 3 sheets), a sheet ed cross sections and 24 cuts in the text. 8O, pp. 145, 1882.

) ATLAS to report on Bucks and Montgomery counties, containing s of topographical map of the Neshaminy, Tohickon and Perkiomen asins by the Philadelphia Water Department on a scale of 1,600 feet h, $\frac{1}{19200}$ of nature. 8O, 1887.—(Report C. 7. not ready for publication.)

rt I of (historical introduction to) a report on the AZOIC rocks, by unt. 8O, pp. 253, 1878.

eport on the kaolin deposits of CHESTER and DELAWARE counties, ual Report, 1885.

eport on the Serpentines of Radnor township, Delaware Co., &c., see , 1886, Part IV.

so GRAND ATLAS, Div. V., Pt. I, under North-eastern and Middle lvania.

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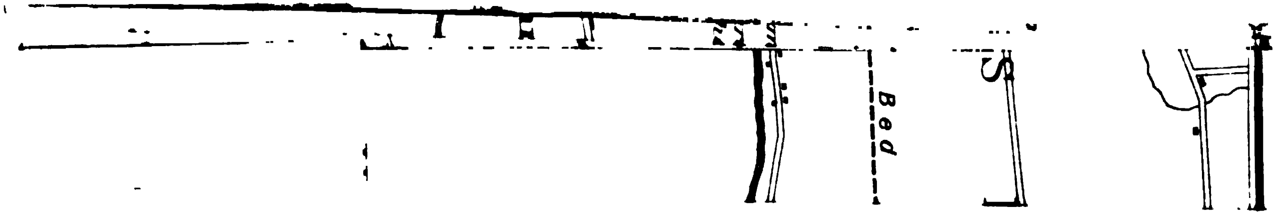

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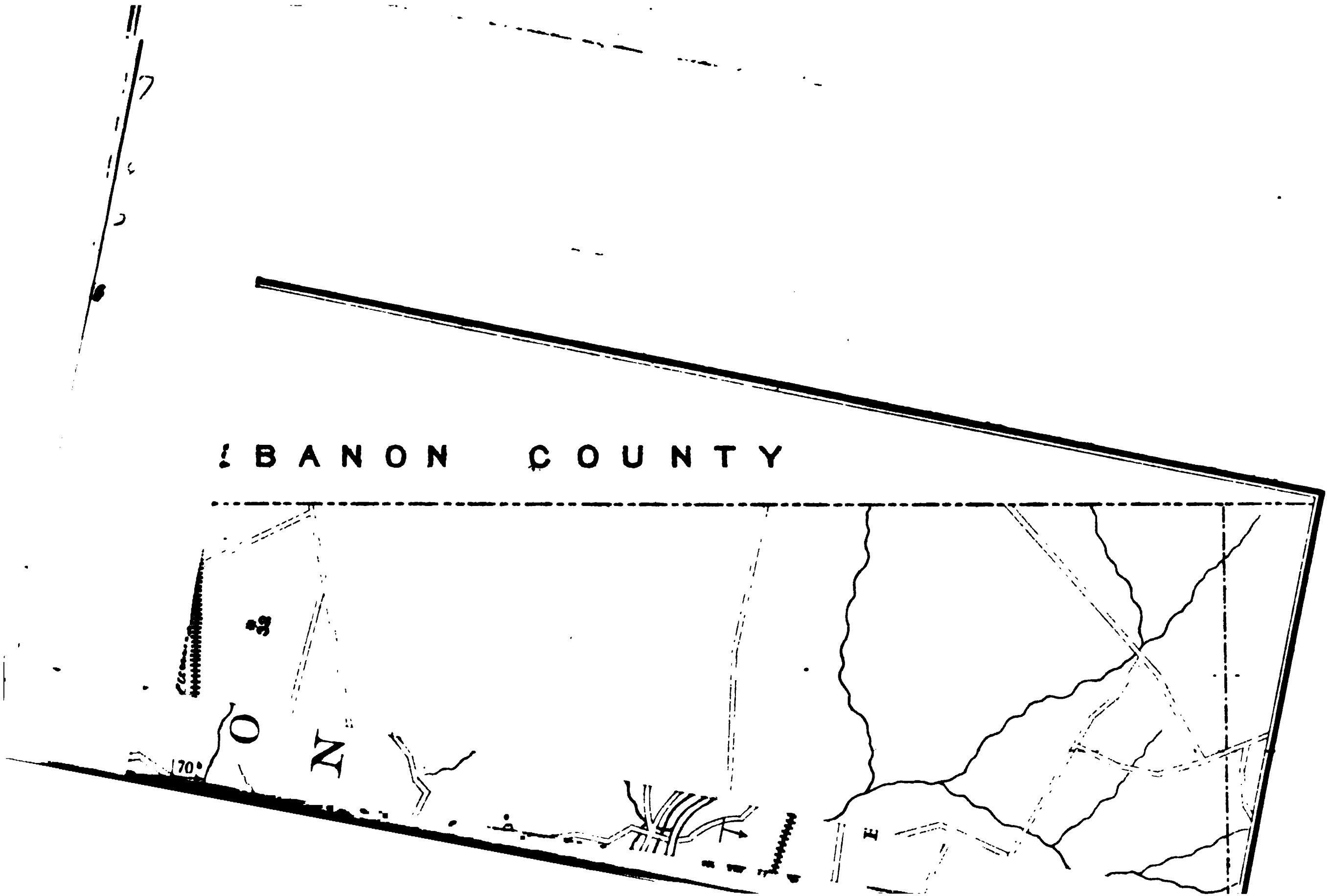
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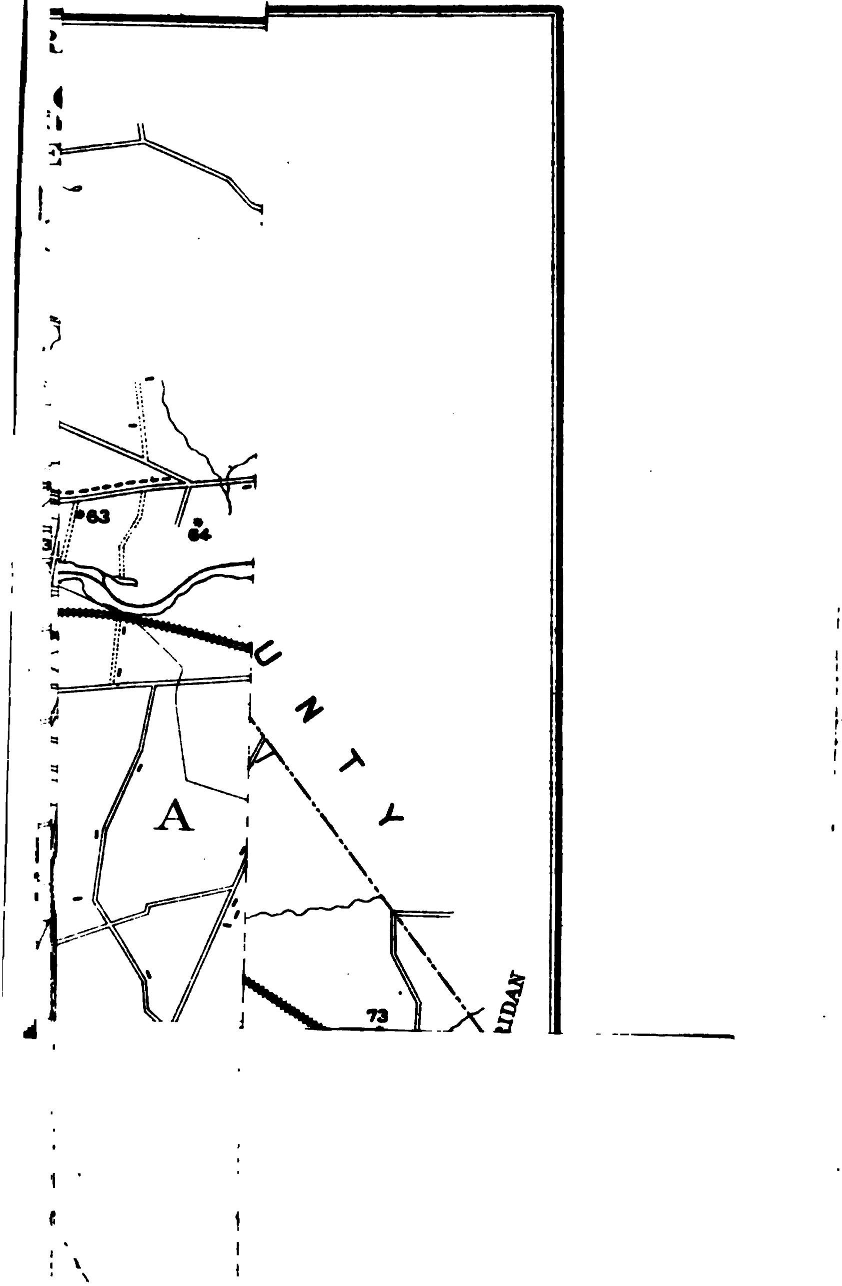
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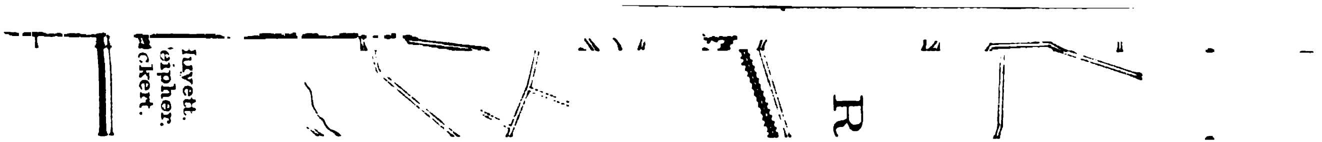

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REFERENCE MAP, LIMESTONE QUARRIES OF BERKS COUNTY.

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